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SEPTEMBER, 1988
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BAMBOO SPECIAL–I

FRONT COVER

DENDROCALAMUS MEMBRANACEUS, NEW FOREST, DEHRA DUN.

Photo—M.D. Dhoundiyal

CONTENTS

EDITORIAL 487

ARTICLES

MANAGEMENT OF BAMBOO FORESTS.
A.N. Chaturvedi 489

RETRIEVAL OF BAMBOO FORESTS IN MADHYA PRADESH.
Ram Prasad and S.K. Chadhar 496

DISTRIBUTION OF BAMBOO UNDER THE EDAPHIC AND CLIMATIC CONDITIONS OF BANGLADESH.
M.M. Hassan, M.K. Alam and A.H. Mazumder 505

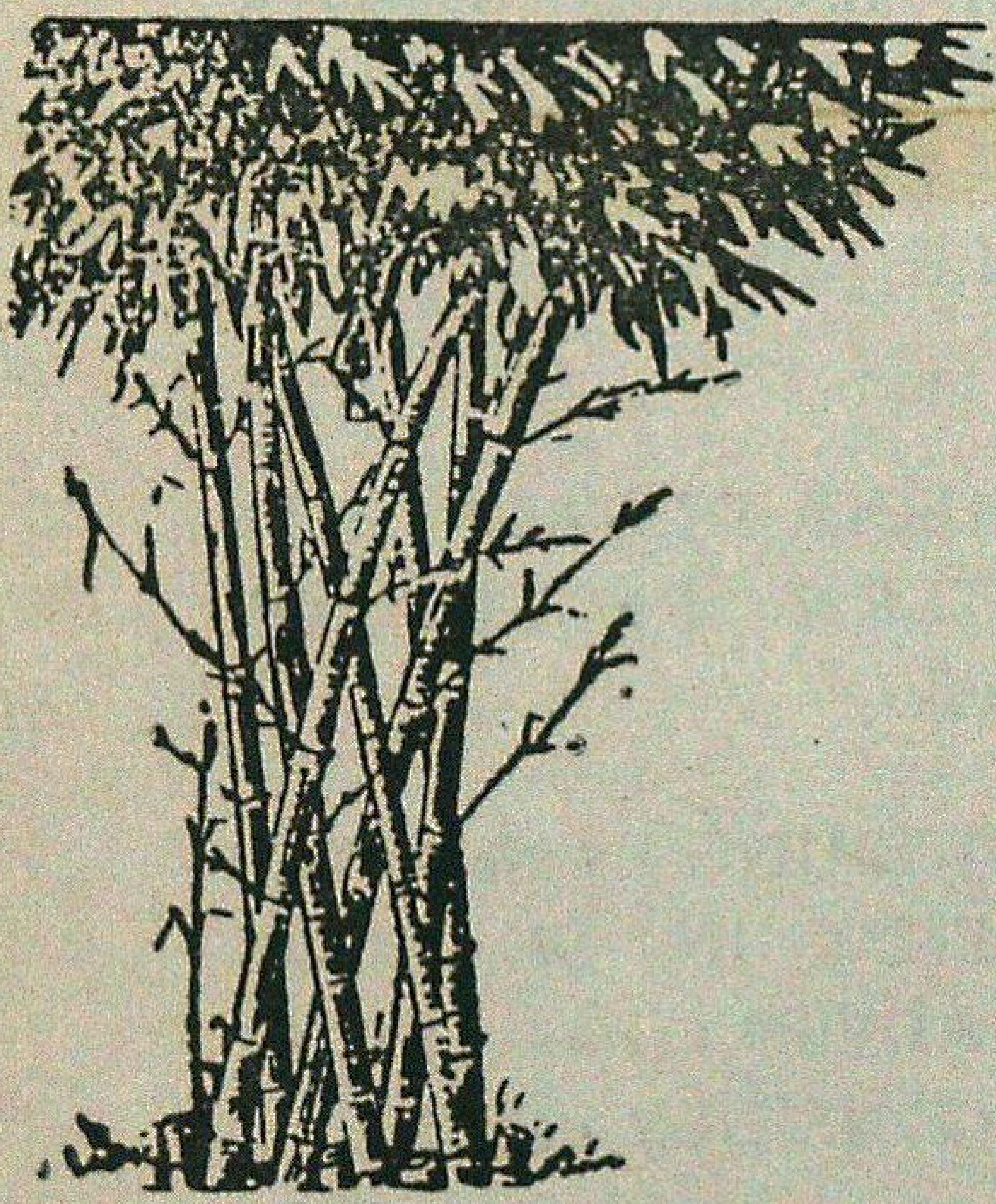
STUDIES ON BAMBOO DISTRIBUTION IN NORTH-EASTERN REGION OF INDIA. Sas. Biswas. 514

GREGARIOUS FLOWERING IN *DENDROCALAMUS STRICTUS* IN SHAHDOL (MADHYA PRADESH) — SOME MANAGEMENT CONSIDERATIONS.
A.P. Dwivedi 532

GENETIC RESOURCES OF BAMBOOS—AN INDIAN PERSPECTIVE.
S. Mauria and R.K. Arora... 539

BAMBOO IMPROVEMENT WORKS IN ARUNACHAL PRADESH.
B.S. Beniwal and N.B. Singh 549

HYDRATION - DEHYDRATION TREATMENTS FOR IMPROVED SEED STORABILITY OF BAMBOO (*DENDROCALAMUS STRICTUS* L.)
Kalpana Sur, A.K. Lahiri and R.N. Basu... 560



VEGETATIVE PROPAGATION OF *DENDROCALAMUS STRICTUS* THROUGH MACRO-PROLIFERATION.
Adarsh Kumar, B.B. Gupta and D.S. Negi... 564

VEGETATIVE PROPAGATION OF *BAMBUSA TULDA* USING GROWTH PROMOTING SUBSTANCES.
Adarsh Kumar, Meena Dhawan and B.B. Gupta 569

INVESTIGATION ON THE CULM PRODUCTION AND CLUMP EXPANSION BEHAVIOUR OF FIVE BAMBOO SPECIES OF BANGLADESH.
Ratan Lal Banik 576

EFFECT OF NUTRIENTS ON THE GROWTH BEHAVIOUR OF *BAMBUSA TULDA* IN THE NURSERY.
A.K. Raina, K.G. Prasad, S.C. Pharasi, K.S. Kapoor and S.B. Singh 584

EFFECT OF NITROGEN AND PHOSPHORUS FERTILIZATION ON *DENDROCALAMUS STRICTUS* SEEDLINGS.
N.G. Totey, Arun Prasad, K.S. Kapoor, P.K. Khatri, J.S. Chauhan, A.K. Bhowmik and V.K. Dahia 592

LETTERS TO THE EDITOR 601

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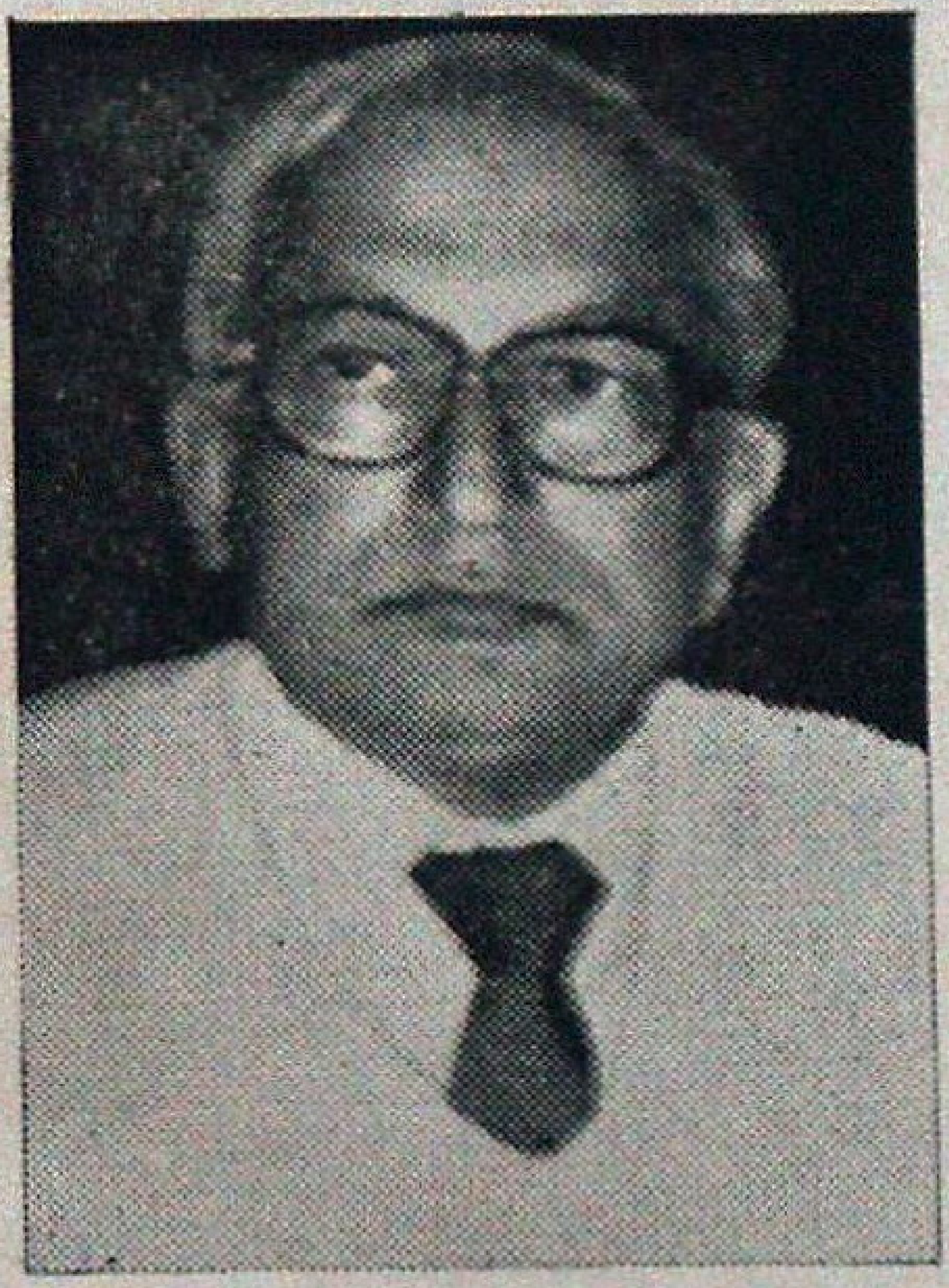
VOLUME 114 NUMBER 9

THE
INDIAN FORESTER
SEPTEMBER, 1988

EDITORIAL



We offer our heartiest felicitations to Shri A.G. Oka, I.F.S. on his promotion to the post of Inspector General of Forests, Ministry of Env. and Forests, Govt. of India, New Delhi. We are happy to welcome him as the new Chairman of the Board of Management of the *Indian Forester*.

Shri Oka passed out from the Indian Forest College, Dehra Dun in 1954 and belongs to Maharashtra Cadre. He held many responsible posts in the State. He joined Govt. of India as Addl. Inspector General of Forests in February, 1987 and took over as Inspector General of Forests in September, 1988.

We wish him a successful term in high office and look forward to inspiring guidance and encouragement under his stewardship, as the new Chairman of the Board of Management of the *Indian Forester* and as the highest executive of the forest service in the country.

* * *

Bamboo plays an important role in the economy of the country and is used for a variety of rural purposes. Bamboo is associated with mankind since ancient times and is a natural gift to the people. Every part of the bamboo is utilized in one way or the other and it has a high calorific value of 4600 to 5400 cal/kg which makes it an energy crop.

India has perhaps the world's richest resources of bamboos, having about 130 species occurring over an area of 9.57 million ha. This is about 12.8 per cent of the total forest area of the country and represents 20% of India's total production. Bamboos are widely distributed in Andhra Pradesh, Arunachal Pradesh, Assam, Karnataka, Kerala, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, Orissa, West Bengal and Madhya Pradesh.

Bamboo is very popular due to its multiple uses, fast growth, easy propagation, soil binding properties, short rotation and it can reduce pressure of fuel, fodder and small timber from the forest areas. Therefore, there is an urgent need for improvement and conservation of different species of bamboo.

Forest Research Institute has maintained the richest collection of bamboo germplasm. It has conserved more than 35 species which are under investigation for taxonomical breeding, timber engineering, pulp and paper technology. Research on silviculture, tissue culture and flowering of bamboo for quick multiplication is also in progress.

This issue covers distribution, propagation, silviculture, genetics and management of bamboo and the coming issue (October, 1988) will cover the utilisation and protection aspects.

G.P. Maithani
Hony. Editor.

MANAGEMENT OF BAMBOO FORESTS

A.N. CHATURVEDI

Tata Energy Research Institute, New Delhi.

Introduction

Bamboo forests occupy large tracts of land in India. Bamboos have also been planted at a sufficiently large scale in many states of the country. There are many natural bamboos species as well as exotics which has been introduced over several centuries. Amongst the many bamboo species found in India the ones that are of commerical importance are as follows :

1. *Bambusa arundinacea*
2. *Bambusa vulgaris*
3. *Bambusa tulda*
4. *Dendrocalamus strictus*
5. *Melocanna baccifera*
6. *Oxytenanthera stocksii*
7. *Ochlandra travancorica*
8. *Thyrsostachys oliveri*

The flowering cycles of these bamboos vary from 7 years to 60 years except for *Bambusa vulgaris* which has not gregariously flowered in India for the past 90 years. Bamboo forests were managed primarily for local use till about the year 1940 when bamboo started being used a raw material for paper. Much larger forest areas started being worked to meet the increasing demands of bamboo for the paper industry. For managing bamboo forests certain silvicultural aspects of these species need to be considered.

Flowering and growth

Bamboos differ significantly from other vegetation because of the mechanism of flowering. Generally most bamboo species flower gregariously at fixed intervals and all culms including those of current year die after flowering. Majority of the bamboos fail between the two physiological states of constant flowering and constant sterility. Example of the former is *Bambusa atra* and that of the latter *Bambusa vulgaris.* Some bamboos die within two years after flowering like *Bambusa arundinacea* while others do not die but their growth slows down during the flowering period as in *Phyllostachys* and *Arundinarias*. Most bamboo species, however, have a more or less sharply defined flowering cycle of 3, 7, 11, 15, 30, 48, 60 or 120 years. This flowering is like setting an alarm clock which is set to go off at a particular time when all populations of a given species raised from the same seed source, no matter where they are situated, would start flowering at the same time. Seeds of *Thyrsostachys oliveri* that flowered in Burma in 1891 were sown at Calcutta and Dehra Dun 1500 kms away from each other. The clumps raised from these seeds flowered simultaneously at Calcutta and Dehra Dun in 1940. These flowered again in 1987–88. These indicate of a flowering cycle of about 48 years. *Dendrocalamus strictus* is known to flower both sporadically and gregariously at long intervals of 20–65 years. The period between two gregarious flowering over the same area for a species is called its physiological cycle.

This cycle is more or less constant for a particular provenance of a given species. In case of sporadical flowering only the culms that flower die and not the entire clump. This is the case with *Bambusa vulgaris* where only sporadic flowering has been noticed. In the case of gregarious flowering, the whole clump dies, the rhizome from which the culms arise also dies after the ripe seeds have fallen.

Clump and Culms

Most bamboo species of commercial importance form clumps. The new seedling produces rhizomes which develop new rhizomes that produce culms. New rhizomes are produced from the previous years rhizomes. The number of new rhizomes may vary from one to many. Some seedlings fail to produce clumps. This may be due to selfing depression. Unlike a tree, bamboo does not acquire more girth as it grows; the new sprout emerge with full diameter. It reaches full height in 60 to 120 days. In India new culms generally appear during the rainy season. An unusual rain during the winter months may induce the emergence of new culms. Though the culms do not grow in diameter after sprouting, they continue to change in density and strength properties. Two kinds of buds are observed on the rhizomes, the scaly pointed buds and the flat buds. The former develop into rhizomes and the latter into culms. The scaly buds are formed during the summer months while the culm buds develop during the winter months. The culm buds emerge out of the soil with the early rains and grow rapidly. It is mostly the youngest rhizomes which produce the culms, they give rise to either scaly pointed buds or flat buds at a time and seldom both of these develop simultaneously. The previous years rhizomes take very small part in the subsequent production of new culms. In rare cases where climatic conditions are very favourable, sometimes three year old rhizomes may produce culms. The culms are very tender during the growing period. They are sometimes cut and made into vegetable or pickles. At this stage there is no terminal bud in the culm. Height growth is caused by the successive elongation of the internodes. The basal internode is the first to grow and the top-most one is the last. However, several internodes from the bottom upwards grow simultaneously and 40–50% of daily height growth is contributed by only 4–6 internodes. The internodes are most carefully wrapped up in sheaths. It is usually after completion of 65-75 per cent of their height that the internodes become visible above the edges of the sheaths. Early exposure of internodes from sheaths results in stunted growth of the culm. The base of an internode is the most active part so far as growth is concerned. The age of an individual culm is not related to clump age. Culms are tender during first year. They grow tough during the second year and are mature during the third year. At the age of three years they acquire full density and strength. After this age they start changing colour. Depending on the climatic conditions and the species culms dry up in 4 to 12 years. They die up earlier in dry localities and have a longer age in moist localities.

Rhizomes

Rhizomes generally grow at an upward inclined angle. The angle of incline depends on the species and the conditions of soil. During this period of growth any exposure to sunlight stops the rhizomes development. Consequently, the bamboo culms that are covered with earth or humus produce more culms while in areas where soil erosion takes place, the production of new culms gets reduced. The rhizome development is not peripheral as generally believed. Rhizomes may develop in any direction and the culms may appear any where in the clump provided overhead light is available for the emergence of the culm. It is only in congested clumps that the new culms appear to grow at the periphery. The new culms can even be seen in the middle of the clump.

Coppicing

The green culms produce coppice shoots after cutting. These are thinner than the culms. These are covered with culm sheaths and are sometimes difficult to distinguish from the actual culms. These are sometimes referred to as switches. Coppice shoots are produced by injury to young culms also. Green culms of all ages may produce coppice shoots. If dry culms are not removed from a clump, the coppice shoots produced from such a clump may cause congestion.

Congestion

Congestion in bamboos in one of the most serious problems of management of clumps. Damage by human agency is probably one of the main causes of congestion in bamboos. In bamboos heavy and irregular cuttings make the bamboos non-workable. Non-working causes further congestion and the vicious cycle continues.

Working Plan Prescription

In several working plans for the management of bamboo plantations, it is laid down that the first working should start from 10-12 years after planting. This is a very undesirable prescription and most clumps are found congested in the very first year of working. In most bamboo forests, the cutting cycles is kept from 3-4 years. It is also prescribed that a Coupe which is not worked in the year when it is prescribed will only be worked when it is due in the next cycle. Thus these culms remain unworked for several cutting cycles. This results in the presence of many dry culms as well as large number of coppice shoots which develop from the dying culms. Many working plans also prescribe retention of a minimum number of old culms varying from 6-10 for providing support to the new culms. Development of new culms, however, takes place nearer the previous years culms. Consequently, the culms older than the third year do not provide any support to the new culms.

Desired Prescription for Management

New bamboo culms are produced each year. Older culms should, therefore, be harvest each year. Culms older than two years take little part in the growth of new culms. Retention of culms older than two years is, therefore, not needed for the production of new culms. Culms older than three years are fully mature for the desired end use. The following rules should therefore be applied for getting high productivity of the desired quality of culms.

1. All Bamboo culms three years older should be harvested.

2. Harvesting should preferably be done

each year. In natural forests where each year's harvest is not possible, this should be done in alternate years. In the intervening years where work is done after a gap, all the coppice shoots should be removed and intensive cultural operations should be carried out.

3. Where congestion has already set in, the congested culms must be removed even if it leaves only the current year culms.

4. Where the young culms are twisted from the top they should be cut so that the new culms grow freely.

5. No felling operations should be carried out from April to October.

6. Bamboo areas should be strictly protected from local grazing.

7. Mounding or heaping earth around the bamboo culms should be carried out each year before the rainy season.

8. Trees providing light shade to bamboos should not be removed as bamboos grow better under the shade of some trees like, Neem, Siris, Amla and such light crowned species.

9. Bamboo clump should in no case be clear felled. The clear felled clump generally degenerate into a bushy form.

Aerial seedings

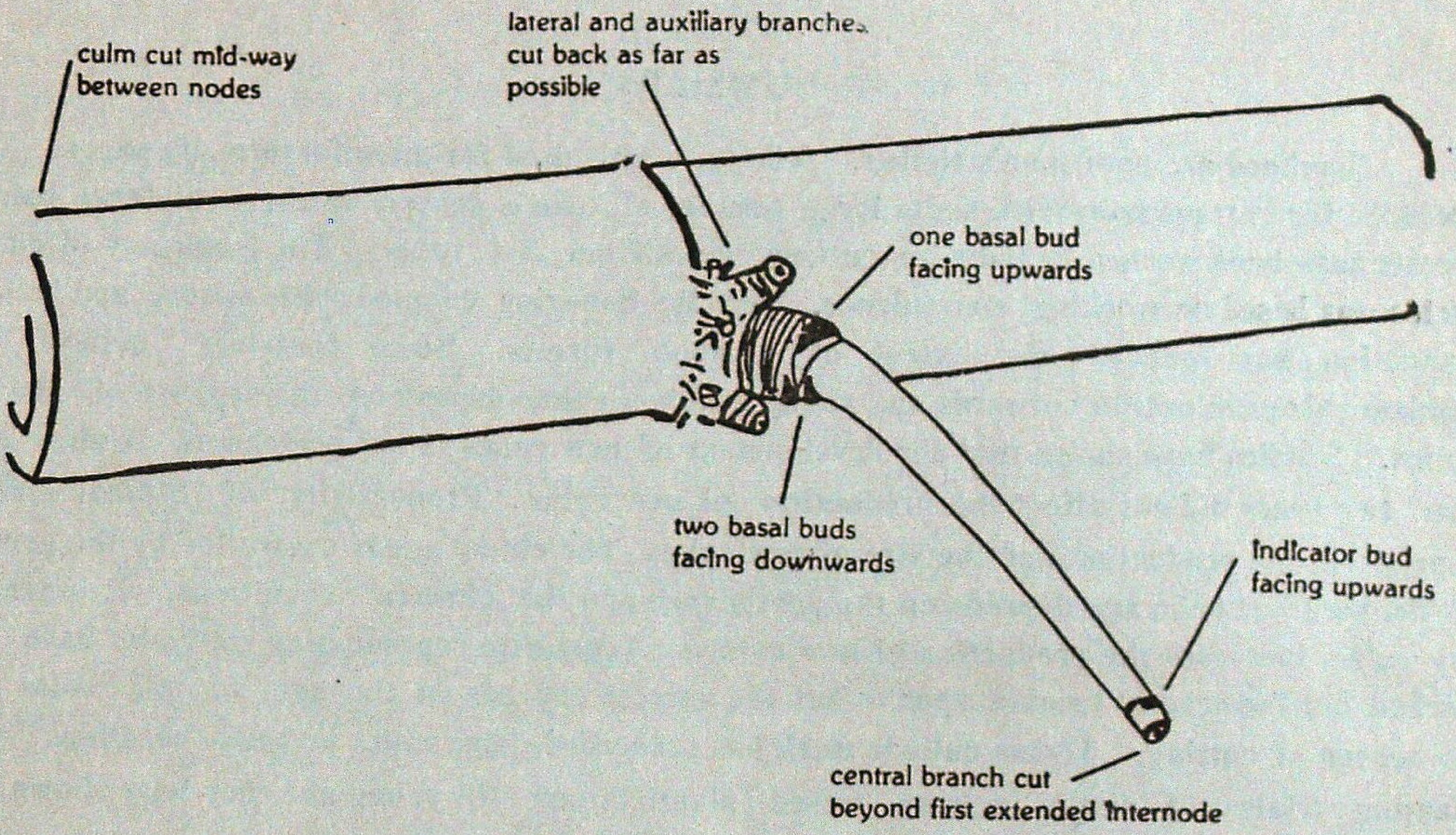
Aerial seedings for regeneration of bamboos was carried out over vast areas in Maharashtra. This turned out to be a total failure. Anybody understanding the silviculture of bamboos should have realized that there was no possibility of this operation ever succeeding. Though germination of the seeds was quite high in certain protected pockets, nowhere could these bamboos form clumps. The rhizomes got exposed to sun and died.

Genotypes

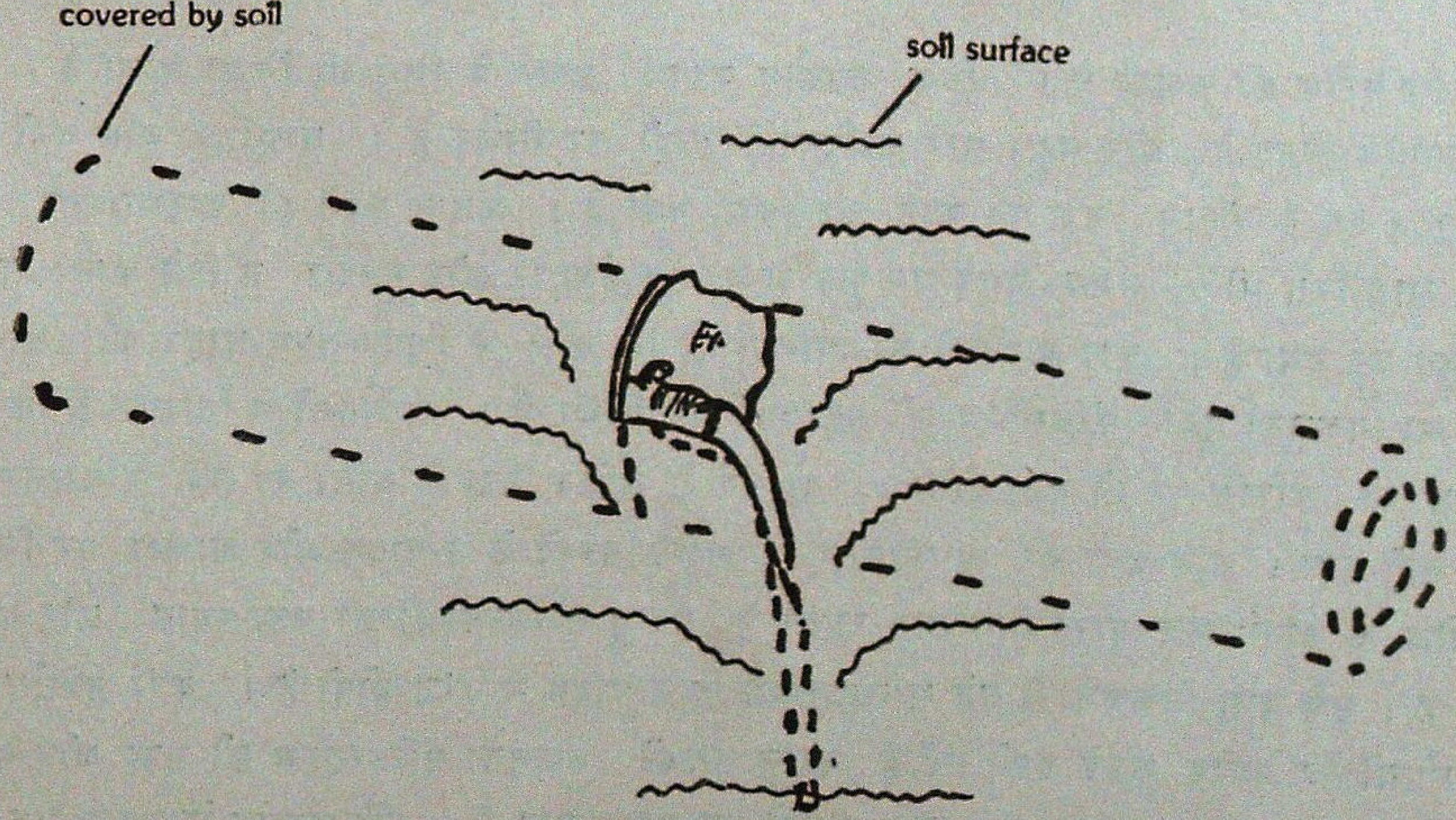
When attempting a plantation of bamboos, it is very essential that the proper genotype is used. Planting can either be done by seed or through the rooted culm cuttings. Bamboos are also often planted through rhizome offsets. This method, however, has a limited use because of the limited availability of the plating material. Rooted culm cuttings can be successful with most bamboo species. The age of the culm and the period when these cuttings are put out for rooting are important considerations. The two year old culms and spring season have been found to give best results. The sketches show the method for rooting of such cuttings.

Tissue culture

Several groups in India have worked on the tissue culture of bamboos. The success in producing plantlets has been obtained only with juvenile seedlings. Efforts to produce plantlets from culms have not been successful so far. Tissue culture work from seedlings is, therefore, of only academic interest. This does not have much practical utility.


culm cut mid-way between nodes
lateral and auxiliary branches cut back as far as possible
one basal bud facing upwards
two basal buds facing downwards
indicator bud facing upwards
central branch cut beyond first extended internode

Prepared single-node cutting of *Bambusa* species.


culm ends well covered by soil
soil surface

Planting technique with culm and branch horizontal and only branch base not covered by soil

SUMMARY

Bamboos are poor man's timber. They are also used for manufacture of paper. They are used for cottage industries and a large number of tribals depend on them. Natural bamboo forests have been worked in India on cutting cycles from 2-4 years. The frequency of cutting cycles was based on working convenience. Periodic flowering coupled with misuse and lack of protection has reduced the extent of bamboo forests. Some foresters believe that bamboo rhizomes extend outwards and young bamboo culms depend on the support of the old culms. Studies have shown that the development of new culms is not peripheral. Culms older than two years did not affect the production of new culms. Productivity of bamboo forests depends on the production and the size of new culms. The clump age is controlled by the genetics of the seed but culm age depends on the provenance and the climatic conditions. Removal of dry culms increases the production of new culms. Vegetative reproduction methods have been worked out for several bamboo species but the success depends on the age of the culm and the season of cutting. Tissue culture work has succeeded only with juvenile seedlings. The planting trials of tissue culture raised plantlets are still young and they have shown wide variability in the quality and quantity of the formation of new culms.

बाँस वनों का प्रबन्ध

ए०एन० चतुर्वेदी

सारांश

बाँस गरीब की लकड़ी है। उनका उपयोग कागज बनाने के लिए भी किया जाता है। कुटीर उद्योग में उनका उपयोग होता है और बहुत सारे आदिवासी उन्ही पर निर्भर हैं। प्राकृतिक बाँस वनों में, भारत में, कार्य उन्हें 2-4 वर्ष के कटान चक्र पर काट कर किया गया है। कटान चक्रों की वारम्बारता कार्य करने की सुविधा पर आधारित थी। समय-समय पर फूल आने, दुर्व्यवहार और सुरक्षा न दिये जाने से बाँस वनों का विस्तार बहुत घट गया है। कुछ वानिकों की मान्यता है कि बाँस के शिफास्तम्भ बाहर की ओर बढ़ते हैं और नये बाँसों का निकलना पुराने संधिस्तम्भ की सहायता पर निर्भर हैं। अध्ययनों ने दिखाया है कि नये बाँसों का विकास बीड़े की परिधि पर ही नहीं होता। दो वर्ष से अधिक उम्र के बाँसों का नये सन्धिस्तम्भों की उत्पत्ति पर प्रभाव नहीं पड़ा। बांस वनों की उत्पादकता नये सन्धिस्तम्भों के उत्पादन और आकार पर निर्भर हैं। बीड़े की आयु बीज के जननशास्त्र द्वारा नितन्त्रित रहती है परन्तु सन्धिस्तम्भों की उम्र स्थान और जलवायु दशाओं पर निर्भर है। सूखे बांस निकलने से नये सन्धिस्तम्भों के उत्पादन में वृद्धि होती है। बर्धी प्रवर्धन विधियां बांसों की कई जातियों पर प्रयोग करके देखी गई हैं परन्तु उनकी सफलता सन्धिस्तम्भ की उम्र और कटाई के मौसम पर निर्भर है। ऊति सवधंन कार्य केवल बाल पादपों पर सफल रहा है। ऊति संवर्धन से उगाए गए पौधों पर किये गए रोपण परीक्षण के पौधे अभी छोटे हैं और नये सन्धिस्तम्भों के बनने में गुण और मात्रा की दृष्टि से बहुत विभिन्नता दिखाई देती है।

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RETRIEVAL OF BAMBOO FORESTS IN MADHYA PRADESH

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Introduction

Bamboo has varied uses. Besides its uses in the cottage industries and agriculture it is one of the most important plant species for the paper and pulp industry. Fortunately, in India there are about 130 species of bamboos (Sharma, 1985). As regards Madhya Pradesh, there are mainly five species, viz. *Dendrocalamus strictus, Bambusa arundinacea, Oxytenanthera nigrociliata, Cephalostachyum pergracile* and *Bambusa vulgaris* but the most widely occurring species is *Dendrocalamus strictus* which covers 18,13,000 hectare forest area of the State (Dutta and Tomar, 1964). Distribution of *Dendrocalamus strictus* in Madhya Pradesh has been shown in Fig. 1. Despite the fact that it is most useful plant species it has been posing difficulty in management and propagation because of the following reasons :

1. Bamboo flowers sporadically almost every year. Flowering in small groups generally remains unnoticed. Even if the collection of seed is made from the sporadic flowering the quantity available is very insufficient for fulfilling the entire plantation requirements of the State. In addition to this, the seed collected from the sporadic flowerings have been found giving lower germination per cent.

2. The gregarious flowering occurs at an interval of 25-40 years. In the period of gregarious flowering, seed is available in huge quantities but cent per cent collection is not done. Further, the entire quantity of seed collected may not be utilised fully because of the limited targets of plantation.

3 After gregarious flowering a large number of seeds germinate but intense biotic pressures do not allow all the germinated seedlings to establish.

For the above reasons the bamboo forests have been shrinking and degrading rapidly while its demand both commercial and domestic, have been on increase.

Bamboo flowering

Management of bamboo forests is greatly affected by gregarious flowering. It is therefore, essential to know the past record of gregarious flowerings. Extent of flowering as also the probable time of the next flowering in different Forest Divisions of Madhya Pradesh have been given in Table 1 (Prasad, 1986).

The interval between two successive gregarious flowerings in bamboo of certain area not only varies with the area but many other unknown factors (Dutta and Tomar, 1964). However, roughly the interval can be accepted to be between 25 to 40 years. From Table 1 it is clear that in most of the forest divisions of Madhya Pradesh the

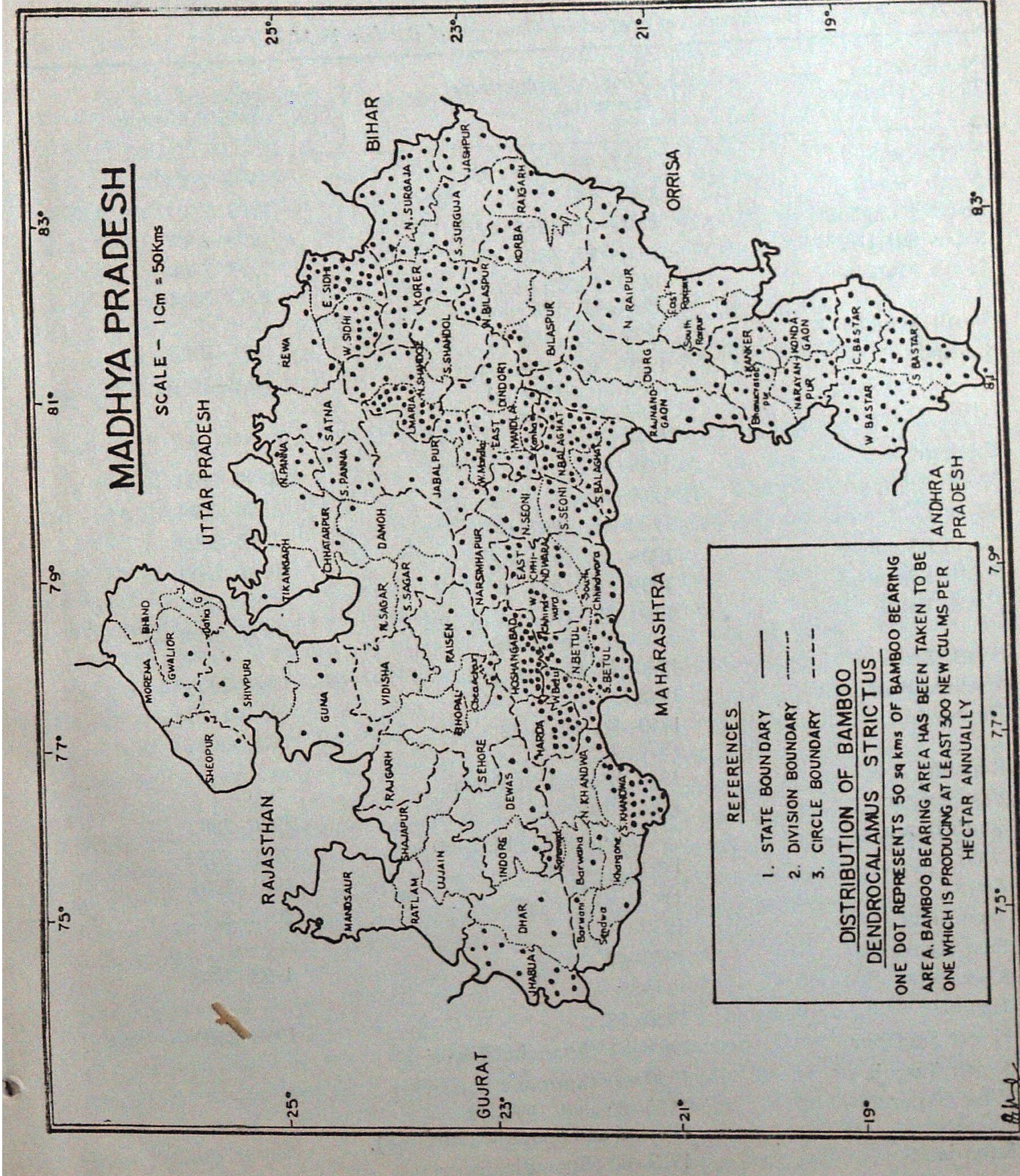
MADHYA PRADESH
SCALE - 1Cm = 50Kms
UTTAR PRADESH
BIHAR
ORRISA
RAJASTHAN
GUJRAT
MAHARASHTRA
ANDHRA PRADESH
25°
23°
21°
19°
75°
77°
79°
81°
83°
MORENA
BHIND
GWALIOR
SHEOPUR
SHIVPURI
GUNA
TIKAMGARH
CHHATARPUR
N.PANNA
S.PANNA
SATNA
REWA
E. SIDHI
W. SIDHI
N. SURGAJA
S. SURGUJA
JASHPUR
RAIGARH
KORBA
KORER
S.SHAHDOL
N.SHAHDOL
UMARIA
N.BILASPUR
BILASPUR
N RAIPUR
East Raipur
South Raipur
DURG
RAJNANDGAON
KANKER
Bhanupratappur
NARAYANPUR
KONDAGAON
C.BASTAR
S BASTAR
W BASTAR
DINDORI
EAST MANDLA
W. Mandla
JABALPUR
DAMOH
N.SAGAR
S.SAGAR
VIDISHA
RAISEN
NARSIMHAPUR
N.BALAGHAT
S.BALAGHAT
N.SEONI
S.SEONI
EAST CHHINDWARA
W. Chhindwara
South Chhindwara
HOSHANGABAD
N.BETUL
S.BETUL
W.Betul
BHOPAL
Obedullaganj
SEHORE
RAJGARH
HARDA
DEWAS
N. KHANDWA
S.KHANDWA
SHAJAPUR
UJJAIN
INDORE
MANDSAUR
RATLAM
DHAR
JHABUA
Barwani
Barwaha
Sendhwa
Khargone
REFERENCES
1. STATE BOUNDARY
2. DIVISION BOUNDARY
3. CIRCLE BOUNDARY
DISTRIBUTION OF BAMBOO DENDROCALAMUS STRICTUS
ONE DOT REPRESENTS 50 sq kms OF BAMBOO BEARING AREA. BAMBOO BEARING AREA HAS BEEN TAKEN TO BE ONE WHICH IS PRODUCING AT LEAST 300 NEW CULMS PER HECTAR ANNUALLY

Table 1

Records of gregarious flowering of Bamboo in M.P.

Name of the Forest Division	Year of gregarious flowering	Next expected year of gregarious flowering
South Seoni	1922–23, 1962–65	1992–2005
North Seoni	1962–64,	1992–2004
North Balaghat	1916–17, 1965–67	1995–2007
South Balaghat	1916–17, 1963–64	1993–2004
South Mandla	1899–1900, 1921, 1944–48, 1963–64	1993–2004
North Mandla	1930–31, 1965–67	1995–2007
Jabalpur	1930–38 (Partial), 1965 (Partial), 1967–70 (Partial), 1972–74	1002–2014
Bilaspur	1960–61	1990–2001
North Bilaspur	1960–61	1990–2001
Sagar	1960–61, 1962–64	1992–2004
North Khandwa	1909–10, 1954–62	1984–2002
South Khandwa	1909–10, 1954–56	1984–1996
North Betul	1940–42 (Partial in 1950), 1967–68	1997–2008
South Betul	1940–42 (Partial in 1950), 1967–68	1997–2008
Hoshangabad	1948	1988–1998
Harda	1950–51, 1942–43, 1976–77	2006–2017
Raigarh	1945 (Partial in 1954)	—
East Raipur	1924, 1960–62	1990–2002
South Bastar	1948, 1980–81, 1957–60	2010–2050
Dhar	1961	1991–2001
Rewa	1982	2012–2022
West Sidhi	1935	—
East Kanker	1965–68	1995–2008
Korea	1940	—
Jashpur	1960–63	1990–2003
North Singhpur	1981–82 (Sporadic flowering)	—
North Surguja	1959–60 (Sporadic flowering)	—
West Bastar	1960–62 and 1976–78 (Partial and Sporadic flowering).	—
Surguja	1959–60 (Sporadic flowering)	—

gregarious flowering has taken place between 1960 and 1970. These areas are likely to have next flowering between the period 1990 and 2005.

Future strategy for maintenance and development of Bamboo Forests

With the increase in various developmental activities the demand for bamboo has risen tremendously. For meeting this demand it is therefore, necessary to take steps to increase the yield of bamboos and for this there can be two ways viz. (i) proper treatment of the flowered areas, and (ii) plantation of bamboos.

Treatment of gregariously flowered areas

Opening of tree canopy : During the period of gregarious flowering large quantity of bamboo seed fall on the ground and profuse regeneration comes up. This dense regeneration is ofted destroyed due to recurring fires, grazing and other biotic factors. As a result, if no precaution is taken, the per cent of total available regeneration which establishes remains quite low. However, this situation can be avoided by adopting proper mangement practices. In the flowered bamboo areas of Kundam Project Division, Jabalpur such steps have shown encouraging results (Hakeem, 1985). In this area the flowering took place in year 1971-73. In the year 1982, the following operations were carried out :

(i) The canopy was opened so as to bring down tree density to 0.4. The removal of trees was done in order of preference removing the economically less valuable trees in favour of well established stems of other valuable species.

(ii) Bamboo seedlings at an espacement of about 4 m × 4 m were adopted and retained and the rest were thinned out.

(iii) Cleaning, soil working and weeding was done around the adopted bamboo seedlings upto a radius of 50 cm.

(iv) To maintain the continuity, planting up of bamboo rhizomes was also resorted to especially in big gaps.

(v) All the flowered clumps were worked up following the prescriptions of the working plan.

(vi) The area was closed for grazing.

(vii) Elaborate fire protection measures were also taken.

Implementation of the above operations resulted in the establishment of bamboo forests. The growth data recorded after two years have been given in Table 2.

As a result of the tree fellings carried out in the area, on an average, timber worth Rs. 9000/ha was obtained whereas the average expenditure incurred on the bamboo regeneration was only Rs. 634.50. These results show that the full advantage of the bamboo regeneration can be taken without incurring any expenditure. This method of developing bamboo forests, which have flowered recently or which have got enough regeneration appears to be a logical answer to the dwindling bamboo resource.

Rhizome bank : The viability of the bamboo seed is the limiting factor for the utilisation of the whole seed yield during the flowering period. However, more seed can be made use of by going for the Rhizome bank technique. In this method the area in which the Rhizome bank is to be established is ploughed and ridges of 15–20 cm height,

Table 2

Clump formation and pattern of Bamboo recruitment after 2 years.

Comptt. No.	No. of clumps per ha.	Average spacing of clumps	Bamboo Recruitment			
			Current year's Bamboo 'Karla'	One year old Bamboo 'Mahila'	Two years old Bamboo 'Pakia'	Total
160	614	4.03	2.00	0.90	0.05	2.95
162	612	4.04	1.20	1.54	0.24	2.98
1963	548	4.27	0.45	2.67	—	3.12
1964	416	4.90	0.68	2.96	—	3.64
Mean	547.60	4.31	1.08	2.02	0.07	3.18
S.D.	92.87	0.41	0.69	0.96	0.12	0.32
SEM	46.44	0.20	0.34	0.48	0.06	0.16

spaced at 30 cm each, are prepared. However, the height of the ridges and the interspace between them will depend on the time upto which the rhizomes are to be used; longer this time more will be the height and spacement. On these ridges seeds are sown at an interval of 5 cm. The seedlings which come up are allowed to grow and each year some of the rhizomes can be taken out with the shoot. These rhizomes can directly be planted out in the field. In third year, each running metre of ridge, on an average, yields about 10 plantable rhizomes (Prasad, 1986). Accordingly, one hectare of such bamboo rhizome bank yields about 3.50 to 5.00 lakhs plantable rhizomes which would be enough to raise bamboo plantation over an area of 500-600 hectares.

Splitting of Bamboo seedlings : Excess seed collected in the year of gregarious flowering can also be sown in the sunken beds. The plants are allowed to grow in the bed upto February. In the month of March, they are individually dugout and split into a number of seedlings, each seedling having one shoot and a number of fresh looking rhizomes. They are pricked out in the polythene bags and kept in storage beds. Watering is done in the usual manner and in due course of time they are ready for planting.

Production of vigorous Bamboo seedlings : An experiment to study the effect of different frequency of trimming of aerial parts of *Dendrocalamus strictus* on the growth and development of sub-terranean rhizomes was taken up by State Forest Research Institute, Jabalpur. In this study four frequencies of trimmings viz. control (no trimming), F_1 (Trimming once in May); F_2 (2 trimmings in April and May); F_3 (3 trimmings in March, April and May) and F_4 (4 trimmings in February, March, April and May) were done in about 4 months old nursery seedlings. About 9 months old seedlings were dugout for measurements of rhizome length and weight. It was reported (Prasad, 1987 b) that frequent trimming has had an adverse effect on the development of rhizome because culm as well as subterranean rhizomes are part of stem. Uchimura (1980) has reported the release of nutrients from the culm to the rhizome. Once the culm (above-ground part of the stem) is severed there is automatic retarded translocation of food material. It is therefore, recommended that as at the initial stage of seedling emergence, the rhizome development is still dependent upon the vigour of the aerial shoot and therefore, chopping off the aerial parts should not be done. However, when plants are 6-7 months old and when a large number of shoots are likely to utilize soil nutrients, some of them may be chopped off without any inhibitory effects on rhizome development.

De-Novo Plantations

De-novo plantation of bamboo is another way for the development of bamboo forests. Method of plantation may vary slightly from one locality to the other. But the standard method consists of sowing the seed in germination beds in the months of September-October and covering them with fine soil, the thickness of the cover being not more than twice the thickness of the dehusked seed. The bed is then covered with straw and watered profusely. Watering may be done two-three times a day but care should be taken that seed bed does not become over saturated. When the seeds have germinated, the cover is removed but watering is continued. The seedlings, when about 7 cm high should be pricked out in the polythene bags. The pricked out seedlings are watered regularly. These polypotted seedlings can be planted out in the field in the next season after the rain has made the soil wet upto a depth of about 15 cm.

Alternatively, direct sowing of seed in the polypots can also be resorted to. By this method also the planting stock can be prepared, the only care which needs to be taken is that the viability of the seed should be assured and time of sowing and the maintenance of the polypots should be strictly observed.

Management of congested clumps

The productivity in bamboo is assessed by the number of new culms produced annually. At a given site the production of new culms is mostly dependent on the culms of the previous year, the degree of congestion and the clump age. In a cleaned and thinned clump new culms grow not only on the periphery but throughout the clump, even in the middle. The clumps which are unduly large and congested usually contain a greater proportion of dead broken and malformed bamboos which are not merchantable (Prasad, 1986 and 1987a). They are removed from the clumps and left in the forest to rot thereby increasing fire hazard. Systematic working of such congested clumps also presents many other practical difficulties. It has been experienced that clumps containing more than 60 culms at the time of working are not easy to work and proportion of unmerchantable culms is also likely to be higher due to congestion and other adverse biotic pressures. In view of the difficulties in working of congested clumps many a times, heavier fellings are resorted to. When clumps are congested they produce a fewer new culms because of lack of growing space. Whatever new culms appear in the year ultimately get twisted and entangled with the older ones. For such congested clumps, therefore, clear-felling appears to be the only solution.

In order to evaluate the effect of clear-felling of such congested clumps on new culm recruitments and annual productivity an experiment was taken-up in Shahdol Division of Madhya Pradesh The congested clumps were clear-felled in March 1977 and debris and othar unsalable material was burnt *in situ*. The area was visited in December, 1980 for enumeration of clumps which had established after clear-felling. Effect of clear-felling on annual recruitment of culms has been summarised in Table 3.

Results of this investigation indicated that for the management of congested clumps the best alternative is to clearfell them and then tend the clumps in such a way that they do not acquire unmanageable size. It is also brought out that a clump containing more than 60 culms creates problem in working as many unexploited culms dry out and become potential fire hazards. They set-in congestion and as a result the new recruitments are also deformed and broken.

Performance of Bamboo on wastelands

State Forest Research Institute has raised plantations of different species of bamboo on various sites of Madhya Pradesh most of which have performed very well. The growth data of the bamboo plantations raised in Amarkantak (high rainfall) region, on 'Bhata land (hard lateritic soils) of Chhattisgarh region and at Jabalpur (Medium soil type) are presented in Table 4.

Thus, though the condition and extent of bamboo forests in Madhya Pradesh is not satisfactory. These forests can be improved if worked on lines suggested above.

Table 3

Annual recruitment of culms

Year	No. of culms	Current years	one year old	2-4 yrs old	Total	Mean No. per clump
1980	33	230 (6.97)	275 (8.33)	441 (13.36)	946	28.70
1981	33	247 (7.48)	317 (9.61)	377 (11.42)	941	28.65
1982	43	206 (3.20)	253 (5.88)	446 (10.37)	905	21.00
1983	42	208 (4.95)	165 (3.92)	608 (14.47)	981	23.38
Mean		37.75	222.75 (5.65)	252.50 (6.93)	468.00 (12.40)	943.25

Figures in parentheses denote the number of culms per clump.

Table 4

Growth data of Bamboo plantation on wastelands

Name of site	Age	Growth Data		
		Average No. of culms/clump	Average Height (m)	Average Girth (cm)
Amarkantak	2	5	2.03	4.80
	3	8	2.19	6.84
Khandwa (Ashapur)	2	2	2.3	3.00
Seoni	7	13	6.5	12.00
'Bhata land' (Bilaspur)	11	15	4.70	7.15
Jabalpur	12	21	—	9.9
Chhindwara	12	25	7.2	13.6

SUMMARY

With the increase in various developmental activities the demand for bamboo has been increased tremendously. To save the shrinking bamboo forests and to increase the yield of bamboos the necessary measures have been suggested and discussed.

मध्य प्रदेश में बाँस वनों का बचाव करना

राम प्रमाद व एस०के० चाधर

सारांश

विभिन्न विकास कार्य-क्रमों में वृद्धि होने के परिणामस्वरूप बांस की मांग बहुत अधिक बढ़ गई है। घटते जा रहे बाँस वनों को बचाने तथा बांस की प्राप्ति में बढ़ोत्तरी करने के लिए इस अभिपत्र में आवश्यक उपाय सुझाए और विवेचित किए गए हैं।

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DISTRIBUTION OF BAMBOO UNDER THE EDAPHIC AND CLIMATIC CONDITIONS OF BANGLADESH

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Introduction

Twenty-two bamboo species under nine genera have been reported to occur throughout Bangladesh (Gamble, 1896; Hooker, 1897; Prain, 1903 and Brandis, 1906) which lies on both sides of the Tropic of Cancer and the 90°E meridian. The variability of climate between the bamboo growing zones is mild. The relationship of the distribution of various bamboo species in Bangladesh and their edaphic and climatic variations has been examined in this paper.

Major bamboo species as given in Table 1 have been discussed.

A few of these bamboo species occur naturally on the eastern and northern hills and several of them are cultivated elsewhere in Bangladesh. Only a scanty knowledge is available about the sources from where they have been introduced to the present habitat. Human migration and settlement history of the past in this region has probably contributed much to the present-day-distribution of bamboo species.

Purposeful planting of the useful species has brought about the widespread distribution in cultivation. The ancestors of the bamboo species have probably descended from Assam, Tripura, West Bengal in India, Burma, Thailand, Indo-China, South East Asia, etc through the trading routes.

Climate

The rainfall, temperature and computed evapotranspiration data for Dhaka, Sylhet, Chittagong and Rangpur weather stations are presented in Table 2. These are representative for the Bangladesh climate.

Bangladesh belongs to a moist sub-humid megathermal climate having a little or no moisture deficit period (Thornthwaite, 1948). It has the following four hydrologically different seasons (Anon., 1971).

(i) The pre-monsoon season (April-May) : has the highest temperature and evaporation rate but low rainfall.

(ii) The monsoon season (June-September) : has the highest rainfall, humidity and cloudiness.

(iii) The post-monsoon season (October-November) : It is hot, humid and sunny but has night dew fall.

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Table 1

Bamboo genera and species of Bangladesh (adopted from Alam) 1982, and three rhizomatous grasses.

Genera	Species
Bambusa	*B. arundinacea* (Retz.) Willd.
	B. balcooa Roxb.
	B. glaucescens (Willd.) Sieb. ex Munro
	B. longispiculata Gamble ex Brandis
	B. nutans Wall. ex Munro
	B. polymorpha Munro
	B. teres Buch.-Ham. ex Munro
	B. tulda Roxb.
	B. vulgaris Schrad.
	Bambusa sp. (Tengra—not identified)
Dendrocalamus	*D. giganteus* Munro
	D. hamiltonii Nees et Arn. ex Munro
	D. longispathus (Kurz) Kurz
	D. strictus (Roxb.) Nees
Melocanna	*M. baccifera* (Roxb.) Kurz
Melocalamus	*M. compactiflorus* (Kurz) Benth & Hook.
Neohouzeaua	*N. dullooa* (Gamble) Camus
Oxytenanthera	*O. nigrociliata* (Buse) Munro
Rhizomatous tall grasses	*Erianthus ravennae* Beauv.
	Pragmites karka Trin.
	Saccarum spontaneum Linn.

(iv) The dry season (December-March) : is cool, dry and sunny.

Soil moisture regimes

The soil moisture regimes (Anon., 1975) representative for Bangladesh are Aridic on steep hill slope, Aquic in flood-plains and Udic to Ustic on terraces (Table 3).

Bangladesh has a hyperthermic soil temperature regime (MAT 29°C) excepting the southern tip where the soil temperature regime is isohyperthermic. Temperature variation between the places within Bangladesh is not, therefore, a serious constraint for the growth and regeneration of bamboos found in this country.

Table 2

Total seasonal rainfall, evapotranspiration and mean temperature data of four weather stations of Bangladesh

Weather data	Pre-monsoon (April-May)	Monsoon (June-Sept.)	Post-monsoon (Oct.-Nov.)	Dry season (Dec.-March)
Dhaka				
Rainfall (mm)	385.0	1330.0	192.0	90.0
Temperature (°C)	28.9	28.6	25.3	21.3
Evapotranspiration (mm)	335.0	660.0	212.0	348.0
Sylhet				
Rainfall (mm)	998.0	2965.0	272.0	170.0
Temperature (°C)	26.5	27.5	25.5	21.0
Evapotranspiration (mm)	149.0	161.0	106.0	50.0
Chittagong				
Rainfall (mm)	363.0	2136.0	271.0	72.0
Temperature (°C)	28.0	28.0	27.5	22.0
Evapotranspiration (mm)	317.0	638.5	229.0	271.0
Rangpur				
Rainfall (mm)	190.5	386.0	82.5	13.0
Temperature (°C)	27.2	28.4	22.5	20.0
Evapotranspiration (mm)	159.0	134.0	102.2	40.5

Table 3

The soil moisture regimes in relation to different landforms and the bamboo species they support

Landform	Soil moisture regime	Bamboo species	No. of consecutive dry days
Hilly region			
Slope (>30%)	Aridic/Ustic	All species	90-175
Slope (<30%)	Ustic	All species	>90
Upland terraces			
Deeply weathered	Udic/Ustic	All species	±90
Shallowly weathered	Udic	All species	<90
Floodplains			
Platforms	Udic	All species except *M. baccifera*	<90
Plains (poorly drained)	Aquic	None	0 (Flooded)
Basin bottoms (very poorly drained)	Paraquic	Rhizomatous tall grasses	0 (Flooded)

Deeply weathered = Altered down to more than 1 m depth, Dry day = No. of days the soili remans biologically dry after the winter solstice.

Soils of Bangladesh

The soils of Bangladesh which support bamboos are scattered on three different physiographic units. These are the hill soils, terrace soils and floodplain soils.

(a) *The hill soils* : The Mio-Pliocene hills of Bangladesh covering the eastern part are steeply sloping and strongly dissected. Soils occurring on the hill summits and slopes are well-drained, and those in the valleys are poorly drained. The hill soils are classified as Orthic or Lithic Tropodults/Haplaudults and the valley soils as Dystric Ha l quepts/Tropoquepts.

(b) *The terrace soils* : The Plio-Pleistocene terraces in the central and north-western parts of Bangladesh are comprised of well and imperfectly drained soils. The well-drained terrace soils are developed on materials which have beeen subjected to secondary alteration down to 2 m or more depths. These soils occur on undulated to flat, dissected upland. These are classified as Oxic Haplaudulfs/Haplaudults.

The imperfectly drained soils occur on level to undulated topography overlying a dense clay substratum within 1 m depth. These soils are classified as Haplaquepts/Haplaquents.

(c) *The floodplain soils* : The floodplain soils developed on the recent sediments can broadly be grouped as calcareous and non-calcareous. Calcareous floodplain soils occur on the Ganges sediments. These are seasonally flooded, poorly drained soils occurring in the Ganges meander and estuarine floodplains. They are classified as Eutric Haplaquents.

The non-calcareous floodplain soils occupy the Brahmaputra, Meghna, Jamuna and Tista floodplains. These are seasonally flooded, poorly drained soils occupying the level meander floodplain. They are classified as Typic Haplaquents.

The tidally flooded soils occupy the estuaries of the rivers Meghna and Ganges. These soils are slightly to moderately calcareous. The salinity and depth and duration of tidal inundation increase toward the sea. The soils are Typic Haplaquents. Homesteads in the floodplain occur on artificially raised platforms.

The distribution of different bamboo species on hill and terrace soils are not related to the soil properties. In the floodplain areas, bamboos are cultivated on high ridges, homesteads, highways, embankments, grave yards and on the raised platforms occuppied by the socio-cultural institutions which are not subjected to seasonal flooding. Their distribution is not, however, related to the soil reaction, texture, soil depth, etc. Excepting for the species of rhizomatous grasses none of the bamboo species grows in seasonally flooded soils. The saline coastal soils also do not support any of the bamboo species. However, bamboo on hills and in floodplains can tolerate occasional flush floods.

Relevant properties of bamboo soils occurring on different landforms are summarized in Table 4.

Discussions

Bamboos grow between the latitudes 40° North and South. Though the big bamboo forests occur usually between 15°–25°. High temperature acts as a growth promoting factor for bamboos. The mean annual rain-

Table 4

Properties of Bangladesh soils occurring on different landforms relevant to the growth of bamboos

Landforms	Drainage	Texture	pH	Soil depth	Flooding
Hilly soils					
High hill	Well	Sandy loam/ Sandy clay loam	4.5–5.5	<1 m	0
Low hill	Well	,,	4.5–5.5	>1 m	
Upland terraces					
Deeply weathered	Well	Silty clay/clay	5.0–5.5	>1 m	0
Shallowly ,,	Imperfect	,,	5.0–6.0	>1 m	0-F_1
Floodplains					
Platforms	Imperfect	Silty clay	5.5–7.6	>1 m	0-F_1
Plains	Poor	,,	6.0–7.0	>1 m	F_1-F_2
Basin bottoms	Very poor	Silty clay/clay	5.5–6.5	<1 m	F_3
Tidal floodplains	Very poor	,,	6.5–8.0	<1 m	F_1-F_2

0 = Non-flooded, F_1 = flooding depth less than 1 m, F_2 = flooding depth more than 1 m and F_3 = flooding depth more than 2 m.

Deep soils occur on low (<100 m) hills, shallow soils occur on high hills due to the presence of hard rock and in basin bottoms due to the presence of ground-water within 1 m depth. The Ganges floodplain soils have higher pH (6.5-7.5).

fall needed is 1000 mm and above. However, in tropics a season of at least three months duration with a monthly rainfall of 200 mm or more is needed for good growth of bamboos (Uchimura, 1981). Bamboos grow well in flat, well drained, loamy soils rich in mineral nutrients. Even a wide range of textural variation, and soil depth (Gamble, 1896) however, do not interfere in the normal growth of bamboo provided the drainage, rainfall and temperature conditions are favourable (Qureshi *et al.*, 1969). *B. polymorpha* in Burma and *B. arundinacea* in other trpoical regions grow in boggy or wet soils after drainage improvement. *B. tulda*, *O. albocilata*, *D. strictus* can resist the seasonal draught. Optimum pH range for bamboo is 5.0 to 6.5. Bamboo cannot grow in soil which contain free salt (Uchimura, 1981). Lyall (1928) stated that the geologically younger soils are more suitable for bamboo than the older soils. This is probaly because of higher nutrient status of the younger soils. Smitinand and Ramyarangsi (1980) reported that in Thailand the distribution of bamboo species is related to the major climatic variations, soils fertility and elevation. Gamble (1896) reported that distribution of bomboo in India is related to the rainfall. Although, some species have a very wide range of choice regarding these factors (Troup, 1921; Gamble, 1896), Uchimura (1981) stated that bamboos grow best in areas having a long warm period in autumn. According to him this condition favours nutrient accumulation in the rhizome. Lantican *et al.* (1985) reported that several of the bamboo species in the Philippines prefer moist soils while the others prefer dry soils. Varmah and Bahadur (1980) correlated the preferential distribution of different bamboo species with the climatic zones of India.

Bangladesh has long days in the spring. The mean annual rainfall is high. The monsoon and part of the post-monsoon season (June-September) have the rainfall over 200 mm per month (Table 2). All these conditions are favourable for the good growth of bamboo.

Bangladesh soils are loamy to clayey, mineral rich, acidic to slightly calcareous. Hydrologically, these soils are Aridic to Udic on hills, Udic to Ustic on terraces and Udic to Aquic in the floodplains (Table 3). Except for the seasonally flooded land, the edaphic and climatic conditions of this country are favourable for many bamboo species. The steep slopes which favour rapid run-off provide a drier soil moisture regime (Aridic/Ustic). *M baccifera, B. tulda, B. nutans, N. dullooa, O. nigrociliata, D. longispathus, D. hamiltonii* are the dominant species on hill slopes. *M. baccifera,* a hill forest species has not been tested for its flood tolerance under the Bangladesh conditions. Other hill forest species, however, can tolerate short seasonal flooding.

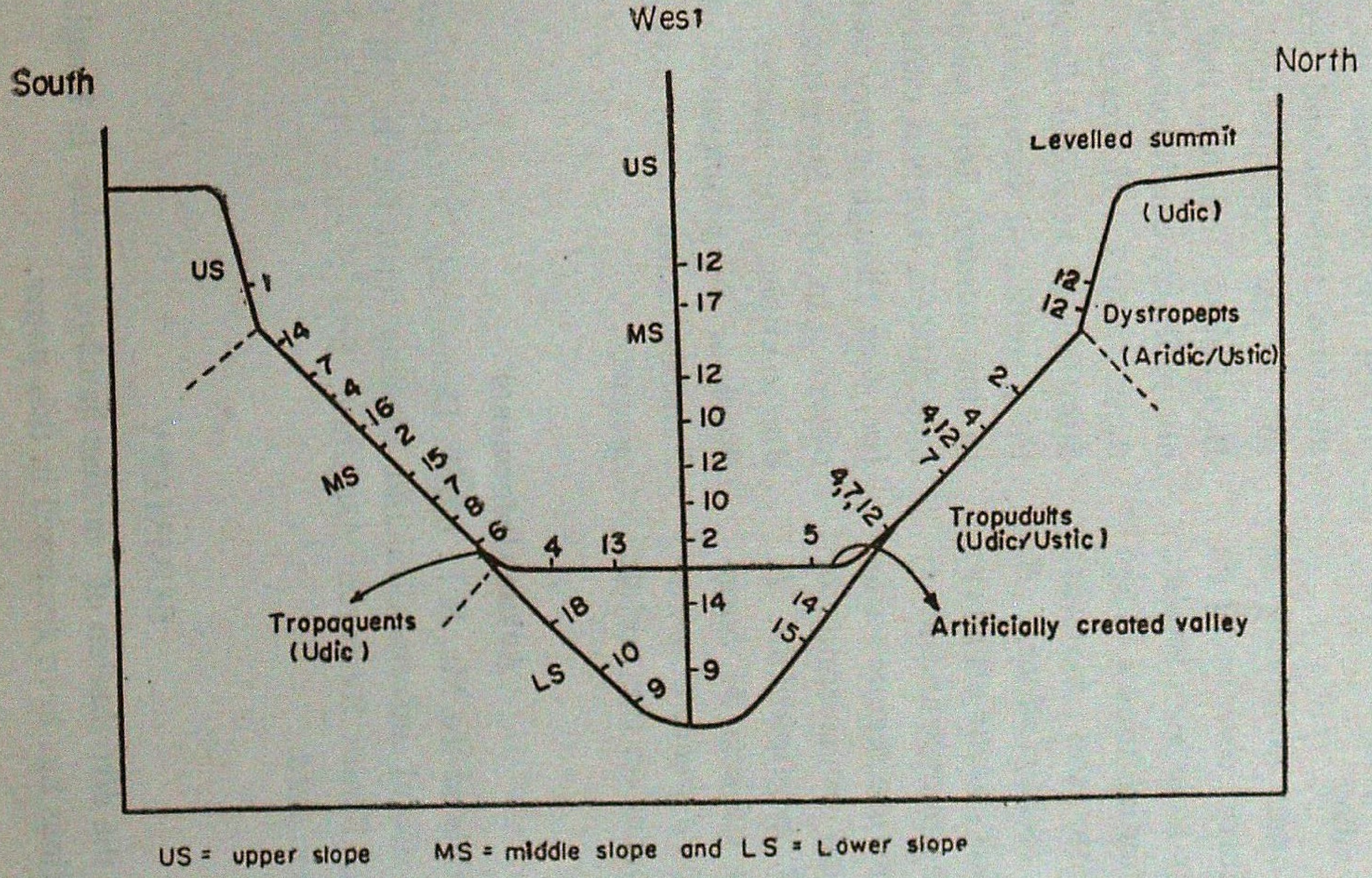
Propagation of bamboo on hill soils takes place through the seeds and rhizomes. Soil texture, soils depth, slope and minor changes in drainage condition do not affect these species very much. *O. nigrociliata* occupies the forest fringes. The difference in edaphic and slope conditions in forest periphery do not apparently affect the growth of this species. This indicates that this species prefers the forest fringe probably because of its high demand for light.

The bamboos grown in the floodplains can tolerate short seasonal floods. Flooding for a larger period are probably harmful to many species. This is evident from the fact that neither the cultivated nor the natural species occurs in the seasonally or tidally flooded areas. Several species of the rhizomatous grasses, however, grow in the perennially saturated and deeply flooded basin bottoms and beels of Dhaka, Chittagong, Khulna and Rajshahi division. In the floodplains, bamboos,are planted from clonal propagules on imperfectly drained, artificially raised platforms. Distribution of bamboo in these landforms is related to the liking of the planters, utility values of the species and availability of the planting materials. Regional concentration of species like *B. balcooa, B longispiculata* in Khulna division, *B vulgaris, B. tulda, B. polymorpha, D. longispathus* in Chittagong and Sylhet divisions and *D. balcooa, B. vulgaris, B. tulda* and *B. longispiculata* in Dhaka division is probably due to the above reasons rather than the preferential liking of the species to the edaphic and climatic conditions of these areas.

A case study

Eighteen bamboo species belonging to three genera have been planted in the Bambusetum of Bangladesh Forest Research Institute, Chittagong (BFRI). It occupies on

Fig. 1


South
West
North
US
MS
LS
Levelled summit
(Udic)
Dystropepts
(Aridic/Ustic)
Tropudults
(Udic/Ustic)
Artificially created valley
Tropaquents
(Udic)
1
14
7
4
16
2
15
7
8
6
4
13
12
17
12
10
12
10
2
14
9
5
4,7,12
4,12,7
4
2
12
12
18
10
9
14
15
US = upper slope MS = middle slope and LS = Lower slope

A schematic configuration of BFRI bambusetum, showing the distribution of bamboo species on the north, south and western slopes and in the valley. Soil groups and moisture regimes in relation to slopes are shown.

LEGEND

1. *Bambusa arundinacea*
2 *B. balcooa*
3. *B glaucescens*
4. *B. longispiculata*
5. *B nutans*
6. *B. polymorpha*
7. *B. tulda*
8. *B. vulgaris*
9. *Bambusa* sp. (unidentified)
10. *Dendrocalamus giganteus*
11. *D. hamiltonii*
12. *D. longispathus*
13. *D strictus*
14. *Melocanna baccifera*
15. *Melocalamus compactiflorus*
16. *Neohouzeaua dullooa*
17. *Oxytenanthera nigrociliata*
18. *Thyrsostachys siamensis*

west-east slope with hills on the north, south and west. An artificial valley has been created on the middle of the slope. The lower slope occurs toward east of the valley. Bamboo planting sites in the bambusetum were selected arbitrarily without paying attention to the edaphic requirement of the species Approximate locations occupied by different species in the bambusetum is shown in the schematic configuration of the area (Fig. 1). Oxic Dystropepts occur on the steep slopes (>30%), Typic Tropudults occur on the middle and lower slopes (>30%) and Dystric Tropaquepts occur in the imperfectly drained valley.

Eroded, acidic, loams overlying an unconsolidated sedimentary rock occur on steep slopes. Hill summits have been levelled for constructing the residential houses. They have an Aridic or Ustic soil moisture regime. *B. balcooa*, *B. longispiculata*, *B. arundinacea*, *B. longispathus* occur on steeps upper slopes. Soils of the middle and lower slopes are deep. Soil moisture regime varies from Udic to Ustic based on steepness of the slope. *B. balcooa*, *B. longispiculata*, *B. polymorpha*, *B. tulda*, *B. vulgaris*, *M. baccifera*, *M. compactiflorus*, *N. dullooa*, *O. nigrociliata* and *D. giganteus* occur on the middle slope The imperfectly drained valley soils are coarse, loamy, acidic having an Udic soil moisture regime. *M. baccifera*, *D. strictus*, *B. nutans*, *B. balcooa*, *D. giganteus* occupy the created valley *D. giganteus*, *Bambusa* spp., *M. baccifera*, *M. compactiflorus* and *Thyrsostachys siamensis* occupy the lower slopes.

In the BFRI bambusetum, different species have been planted on different soils and moisture regimes. These species do not show apparent growth variation. Distribution of bamboos on different slopes, moisture regimes and texturally different soils in the bambusetum and elsewhere in Bangladesh indicates that the bamboos are not probably conditioned by the variation of these factors. However, the depth and duration of seasonal floods possibly limit the growth and survival of bamboos grown in this country. Soil salinity in the coastal area hinders bamboo cultivation. *Melocanna baccifera*, though a very useful species is not observed in the homesteads. This may be due to either the species cannot tolerate flood or its propagation through rhizome transplantation is not easy like the other species.

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SUMMARY

The relationship of the distribution of various bamboo species in Bangladesh and their edaphic and climatic variations has been discussed in this paper.

बंगलादेश की मृदीय एवं जलवायु दशाओं में बांसों का विस्तार

एम०एम० हसन, एम०के० आलम व ए०एच० मजुमदार

सारांश

बंगलादेश में बांसों की विभिन्न जातियों के विस्तार और वहां की मृदीय एवं जलवायु विभिन्नताओं के साथ उनके सम्बन्ध का विवेचन इस अभिपत्र में दिया गया है ।

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STUDIES ON BAMBOO DISTRIBUTION IN NORTH-EASTERN REGION OF INDIA

SAS. BISWAS*

Introduction

Bamboo is indigenously found in all the continents except Europe. It is estimated that about 80% of the bamboo growing areas are confined in South and South-east Asia. The tropical climate of the region is congenial to bamboos and also the limiting factors for their distribution. There are as many as 70 genera and *ca* 1200 species distributed in tropical, sub-tropical and temperate zones of different parts of the globe. Tropical Asia can be referred as the centre of bamboo germplasm with as many as 45 genera and *ca* 750 spp. Indo-Malesian region has *ca* 25 genera represented by about 160 species. North-eastern region has as many as 63 species under 15 genera which are well represented and distributed in Indo-Malesian region (Table 1). There are 26 genera and more than 300 species of bamboos in China (Quantai, 1980).

Table 1

Bamboos in Indo-Malesian Region

Genera	No. of species World over	No. of species in N.E. Region	Distribution
1	2	3	4
Arundinaria	150	10	Asia, Madagascar.
Bambusa	70	17	China, Bangladesh, Burma, India, Thailand, Java, Malay Peninsula, Indo-China, Sabah, Solomon Isl. New Guinea.
Cephalostachyum	12	5	N.E. India, Bangladesh, Burma & Thailand.
Dendrocalamus	20	10	N.E. India, Burma, Thailand, Malay Peninsula, Indo-China.
Dinochloa	20	2	N.E. India, Burma, Thailand, Malay Peninsula, Philippines.
Gigantochloa	20	2	N.E. India, Malay Peninsula, Philippines, Sabah, Thailand, Java.
Melocalamus	1	1	N.E. India, Bangladesh, Burma, Thailand.

(*Contd...*)

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1	2	3	4
Melocanna	2	2	N.E. India, Bangladesh, Burma, Indo-Malaya.
Nastus	11	Nil	Madagascar to Solomon Islands, New Guinea, Sunda Islands.
Neohouzeaua	4	2	N.E. India, Indo-China, Burma.
Ochlandra	12	Nil	South India, Sri Lanka, Malagassy.
Oxytenanthera	20	2 (cult).	Africa, Malagassy, Indo-Malaya
Phyllostachys	40	2	N.E. India, China, Japan.
Pseudostachyum	1	1	N.E. India, Burma.
Racemobamos	10	Nil	Malaya, Borneo, New Guinea, Sabah, Sarawak, Indonesia.
Schizostachyum	25	Nil	Throughout Malesia : New Guinea, Java, Sumatra, Borneo, Philippines etc.
Thamnocalamus	5	4	India, Burma, Thailand.
Teinostachyum	6	1	India, Bangladesh, Burma, Sri Lanka.
Thyrsostachys	2	1 (cult.)	Burma, Thailand.
Yushania	1	Nil	Philippines, Taiwan.

Bamboo diversity

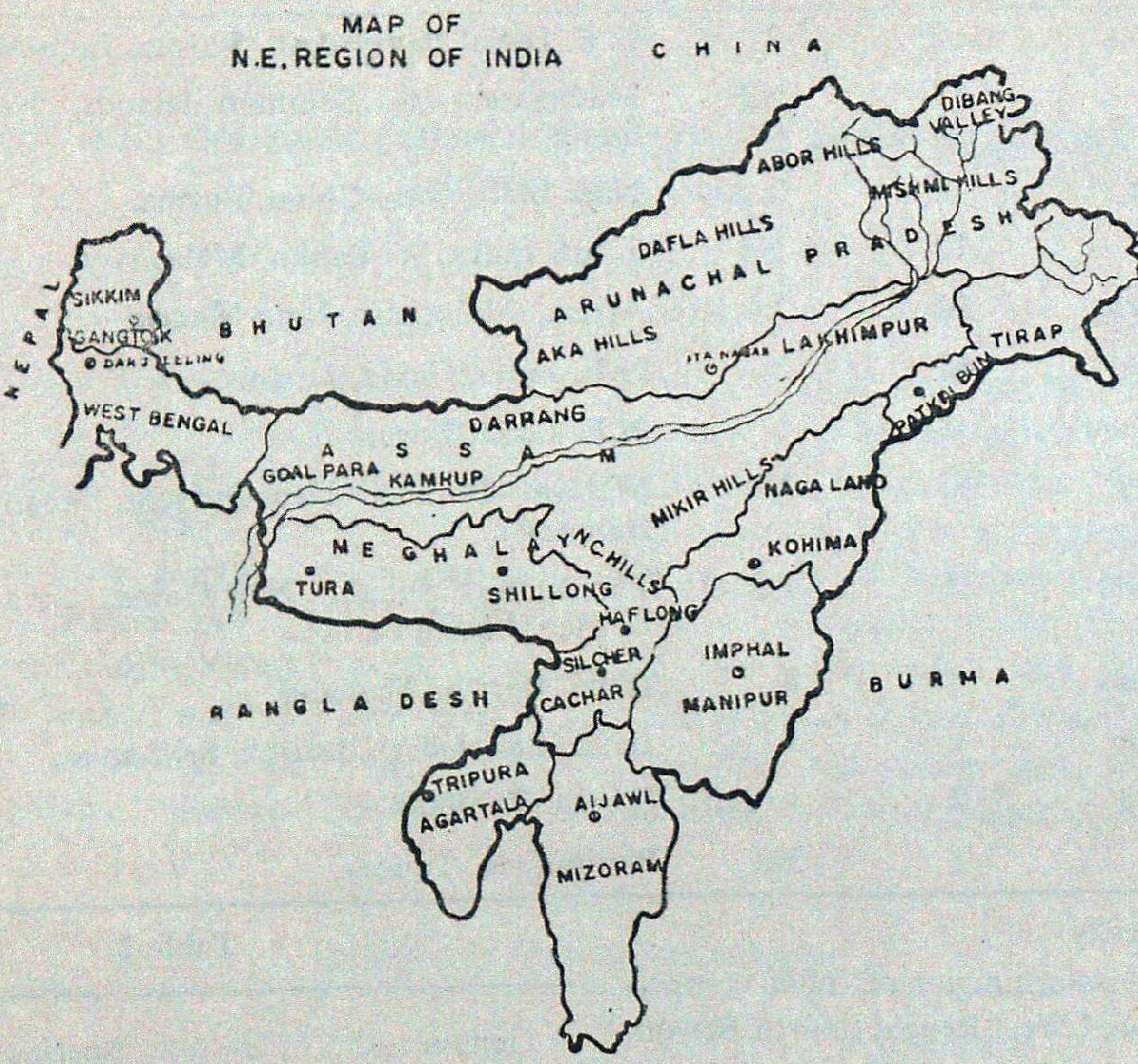
North-eastern region of India comprising the states of West Bengal (North Bengal, Himalaya), Sikkim, Arunachal Pradesh, Assam, Nagaland, Mizoram, Manipur, Meghalaya and Tripura (Fig. 1) has over 50% of bamboo species i.e *ca* 115 of the total species reported from India. The principal genera found in the region are 1. *Arundinaria*, 2. *Bambusa*, 3. *Cephalostachyum*, 4. *Chimonobambusa*, 5. *Dendrocalamus*, 6. *Dinochloa*, 7. *Gigantochloa*, 8. *Melocalamus*, 9. *Melocanna*, 10. *Neohouzeaua*, 11. *Oxytenanthera*, 12. *Phyllostachys*, 13. *Pleioblastus*, 14. *Pseudostachyum*, 15. *Semiarundinaria*, 16. *Sinobambusa*, 17. *Teinostachyum*, 18. *Thamnocalamus*, 19. *Thyrsostachys*. The genera such as *Arundinaria*, *Bambusa*, *Cephalostachyum*, *Chimonobambusa*, *Dendrocalamus* and *Thamnocalamus* are rich in species diversity as shown in Table 2.

Table 2

Genera	Species		
	World	India	N.E. India
Arundinaria	150	10	10
Bambusa	70	22	17
Cephalostachyum	12	7	5
Chimonobambusa	14	9	6
Dendrocalamus	20	15	10
Thamnocalamus	5	4	4

It is evident here that N.E. region is centre of genetic diversity for the species of genera *Bambusa*, *Dendrocalamus*, *Arundinaria* and *Cephalostachyum*. The distribution of genera such as *Melocalamus* & *Pseudostachyum* and the species of *Melocanna* and *Neohouzeaua* in N.E. India and adjoining

Fig. 1


MAP OF
N.E. REGION OF INDIA
CHINA
DIBANG VALLEY
ABOR HILLS
MISHMI HILLS
DAFLA HILLS
ARUNACHAL PRADESH
SIKKIM
NEPAL
GANGTOK
DARJEELING
BHUTAN
AKA HILLS
ITANAGAR
LAKHIMPUR
TIRAP
PATKAI BUM
WEST BENGAL
DARRANG
ASSAM
GOAL PARA
KAMRUP
MIKIR HILLS
NAGA LAND
MEGHALAYA
N.C. HILLS
KOHIMA
TURA
SHILLONG
HAFLONG
SILCHER
IMPHAL
BANGLA DESH
CACHAR
MANIPUR
BURMA
TRIPURA
AGARTALA
AIJAWL
MIZORAM

Map of North-eastern region of India showing different states

regions suggest their origin in Indo-Malesian region. Dogra (1986) mentions that the main factors influencing variability within the species are (i) the size of species range (ii) amount of environmental diversity within the range (iii) extent of discontinuities in the range; and (iv) factors giving rise to little variability in large range species.

Bamboo is not only one of the most useful indigenous products but a most important renewable natural plant resources also. It is beleived that nearly 80% of the bamboos producted in the Asian countries are used by the people. On a conservative estimate the forest area under bamboos in India (including plantations) is 9.57 m ha which is *ca* 12.8% of the total forest area of 75 m ha (Bahadur & Jain, 1983). Emphasizing the importance of bamboos and reeds as cellulosic raw material, Choudhary and Biswas (1987) mention that66% of the pulp being used presently in about 40 Paper Mills in India comes from bamboo. Further, 6-7 times as much cellulosic materials can be obtained per hectare from a bamboo forest as compared to coniferous or other broad-leaved forest. The present treatise concerns the studies on the distribution of bamboos of north-eastern region which can be referred to as the reservoir of bamboos and their diversity. The studies are aimed at revealing and highlighting the useful informations on the concentration, density, genetic diversity, range extensions, physiograpical and phytogeographical status of bamboo species of the region. The present account is based upon author's works on different aspects of bamboo carried in different parts of N.E. Region of India during 1977 to 1987.

Topography & Ecology of North-eastern Region

The region covers a geographical area of approximately 2,67,760 km². with an estimated forest area of 98,350 km². The region has *ca* 14% of the country's forests (under the control of forest department). The countries bordering this part of India are Nepal, Bhutan, China, Bangladesh and Burma. Indo-Chinese and Indo-Burmese borders are most inaccessible and un/under explored areas in the subcontinent. Larger part of the region is hilly, so much so that the Arunachal Pradesh has the highest mountains with altitudes varying from 1200 m to 7300 m. The area is drained by mostly north to south flowing rivers viz. Tista, Brahmaputra and the tributaries of later. The temperature in some parts of the region ranges from below freezing point in winter to over 35°C. Average annual rainfall varies from 13 cm to 300 cm. The humidity or precipitation is one of the main governing factors not only towards the enormous genetic diversity, growth and distribution of bamboo brakes in North-Eastern India but also for the development of complex and varied ecosystems. The present climax codition of different ecosystem of the region after thousands of years maintains a fragile ecological balance which is upset as a result of various biotic factors such as indiscriminate felling, forest fires, grazing, etc.

The physical geography coupled with precipitation, temperature and altitude have a lot towards the diversity and richness of forests of north-eastern part of the country (Choudhury & Biswas, 1987). Broadly the forests of the region can be classified into : (i) Tropical (ii) Temperate and (iii) Alpine type.

(i) *Tropical Forests* : These forests comprise moist and dry deciduous, evergreen and semi-evergreen forests and savannah type of vegetation. These types have been categorised sometimes into (a) Assam Valley tropical wet evergreen forest, (b) Sub-Himalayan tropical semi-evergeen forests, (c) Khasi and Jaintia hills tropical evergreen forests, (d) Eastern Himalayan Sal Forests and moist mixed deciduous forests, (e) Savannah type of vegetation of Khasi and Jaintia hills.

The tree species met within this type of forests are *Shorea robusta*, *Gmelina*, *Bombax*, *Dillenia* spp., *Adina*, *Kydia*, *Bauhinias*, *Cassia*, *Albizias*, *Schima wallichii*, *Lannea*, *Terminalias*, etc. Among the bamboos, *Dendrocalamus hamiltonii*, *Bambusa balcooa*, *B. tulda*, *B. pallida*, *Melocanna baccifera*, *Neohouzeaua dullooa* are quite common. Savannah type of vegetation is due to the biotic factor particularly the grazing and the principal tropical grass genera are *Arundo*, *Chysopogon*, *Cymbopogon*, *Erianthus*, *Saccharum*, *Phragmites*, *Vetiveria*, *Themeda*, etc. Where a great deal of the area has been traversed by *jhuming* (shifting cultivation) the area has degenerated into bamboos brake with *Melocanna*, *Bambusa balcooa* & *Neohougeaua dullooa*. The semi-evergreen and evergreen forests contain the main tree species such as *Amoora, Dysoxylum. Chukrasia, Canarium, Phoebe, Cinnamomum, Castanopsis, Syzygium, Artocarpus, Michelias, Dipterocarpus, Shorea assamica, Garcinia, Lagerstroemia speciosa, Garcinia*, etc.

The montane sub-tropical forests experience a rainfall ranging from 1200-2500 mm. The minimum temperature is 4°C and maximum touches 23°C. Broadly the forests fall under sub-tropical broad leaved hill forests of Sikkim, North Bengal Himalaya and Khasi & Jaintia hills and Assam sub-tropical pine forests The dominant tree species are *Engelhardtia, Quercus* spp., *Castanopsis* spp., etc. *Betula, Pasania* spp., *Cryptocarya.* The pine forest has the admixture of *Pinus kesiya, Exbucklandia, Rhododendron, Persea, Lyonia* etc. The species of bamboo occurring on the outskirts of pine forests and also as an admixture are *Chimonobambusa callosa, C. khasiana, Neouhouzeaua dullooa, Thamnocalamus prainii, Dendrocalamus hookeri, D. sikkimensis, Pseudostachyum polymorphum, Teinostachyum griffithii* etc.

(ii) *Temperate Forests* : These forests are confined to elevations from 1700 to 3000 m. Depending upon various locality factors the temperate forests can be further classified into *Lauraceous*, high level Oak-Hemlock, Coniferous and Birch-Rhododendron forests. Shillong and Darjeeling motane temperate forests experience rainfall of *ca* 3000 mm and the number of cloudy days exceeds 200 in year. The occurrence of temperate type of vegetation at lower altitudes in Meghalaya may be attributed to the fact that climatic factors with regard to altitude vary from one mountain to the other.

The tree species found in laural forest are *Persea* spp., *Betula, Quercus lamellosa, Q. lineata, Alnus nepalensis, Acer* spp., *Engelhardtia* spp., *Castanopsis, Michelia* spp. etc.

The Oak-Hemlock forest consists of mainly *Tsuga, Castanopsis* spp., *Viburnums, Prunus* spp., *Quercus* spp., *Acer sikkimense, A. campbellii*, etc.

The coniferous forests contain mainly *Abies pindrow, A densa, Pinus wallichiana, Larix griffithiana, Rhododendron* spp. *Quercus* spp., etc.

The occurrence of bamboo in these type of forests is represented by the different species of *Arundinaria, Chimonobambusa, Thamnocalamus, Semiarundinaria, etc.*

(iii) *Alpine & sub-alpine Type* : The vegetation is confined to higher ranges from 3000 m to 4500 m. The species commonly found in this region are, *Abies densa, Betula utilis, Juniperus* spp., *Rhododendron* spp.

Distributional patterns & attributing factors

Geographical location and physiographical features like altitudinal variations contribute to the bamboo diversity and the distribution of the species in different bioclimatic regions of north-eastern region of India. Edaphic, climatic and biotic factors play equally an important role towards the distribution of bamboos. Precipitation or humidity developed by rainfall together with temperature is a major factor for the density and growth of bamboo occurring in lower elevations of N.E. India.

Morphological features : Among the main morphological features attributed to the ditribution of bamboos, rhizomes and culms are the propagation forms. These forms are principally calssified into non-clump-forming (leptomorph) and clump-forming (pachymorph) types. The non-clump-forming type is characterised by monopodial rhizomes and culms. Most bamboos of this type are erect and long, for example, *Arundinaria, Chimonobambusa, Semiarudinaria, Phyllostachys* and *Sinobambusa.* These genera are mainly distributed in sub-tropical and temperate regions. The clump forming type includes the genera like *Bambusa* and *Dendrocalamus.* In this type the larger buds present at the lower portion of the culms sprout directly above the ground and the sprouts grow into culms, forming a clump of culms with a short rhizome. In the region of present treatise the bamboo specieswith this type of morphological features are mostly confined to the tropical bioclimatic zone.

Altitudinal variations & soil type : The elevation in north-eastern region ranges from 30 m to 4500 m above sea level. The studies on the distributional patterns of bamboo in the region reveals that the species of *Bambusa, Dendrocalamus, Dinochloa, Cephalostachyum, Neohouzeaua* are mostly confined to lower altitude ranging between 30-600 m whereas the species of *Arundinaria, Chimonobambusa, Semiarundinaria, Sinobambusa, Thamnocalamus, Phyllostachys* are found in higher altitude ranging between 800-3500 m above sea level. It is interesting to note here that the species of certain genera such as *Cephalostachyum* (*C. capitatum, fuchsianum, C. latifolium*), *Dendrocalamus* (*D. sikkimensis, D. patellaris, D. hookeri*) extend their range of distribution into higher altitude This may be due to several factors such as change in climatic and edaphic factors governing the growth of bamboos. Generally the area with high temperature and humidity accelerate the growth of bamboos whereas low temperature inhibits it. It is revealed from the present studies that the diversity at generic and specific levels at the elevation between 1000-3000 m is higher i.e. 16 species distributed among 8 genera than at lower altitude between 30-300 m (10-12 species of 5-7 genera) and higher altitude, 3000-4500 m (6 species of 4 genera). Studies carried on the status of bamboos in Arunachal Pradesh by Haridasan *et al.* (1987) shows that in Arunachal Pradesh 35 species of bamboos are confined to 100-1500 m MSL whereas high altitude, i.e. 1500-3700 m has only 7 species.

Soils with moisture content support the growth, development and distribution of bamboo. Soils high in N, P_2O_5, K_2O, SiO_2 and CaO promote the best growth. The acidic medium of soils (pH 4.5) is good for the growth of culms. A variety of geological parent rocks with the interaction of different climatic types have produced a number of soil types. The soil of north-eastern region varies from alluvial to ferruginous types. Table 3 shows the types of soil found in different parts of North-eastern India and the species diversity.

It appears that the areas with variety of soil types have certain relations not only in diversity in bamboo species but in bearing larger areas also.

Rainfall and temperature : The interyearly variability in amount, distribution and seasons of occurrence of rains and micro-climates play an important role in developing the diversity and bioclimatic patterns (Meher-Homji, 1988). Rainfall necessarily affects the distribution and limits the growth

Table 3

Soil types of North-eastern India

States	Soil Types	Species diverity
Arunachal Pradesh	Ferruginous soil, Mountain meadow soil.	41
Assam	Alluvial soil, Laterite, Forest soil with well decomposed humus and strongly acidic	33
Nagaland	Laterite and Mountain Meadow soil.	23
Meghalaya	Laterite soil deficient in potash and lime, Ferruginous soil, Hill soil with pH 4.5-6.5 i.e. acidic.	36
Mizoram	Same as above and with Forest soil.	16
Manipur	Hill soil and ferruginous types.	20
Sikkim	Brown hill soils (on sand stone & shales) and Mountain meadow soils.	25
Tripura	Alluvial soil varying from clayey to sandy loam, Laterite, Hill and Forest soil	13
North Bengal Himalaya (W. Bengal)	Brown hill soils, Mt. Meadow soils & Alluvial soils (recent).	30

of bamboos than any other component of climate. As discussed earlier temperature in relation with altitude, precipitation and soil moisture affect distribution of bamboos. In higher altitude the direct and indirect influences of low temperatures restrict the geographical distribution of bamboos. This is due to the reason that the low temperature lowers the ability of photosynthesis and the absorption of underground water is high in the roots (Numata, 1987). Low temperature is thus the first limiting factor at the macrolevel. The production of good quality bamboos from the localities in north-eastern region of India have at least 1500-3500 mm of rainfall per year with nearly 70-80% of the precipitation. Following Table 4 provides the average of avatlable climatological data on temperature, rainfall and relative humidity recorded at different localities in north-eastern region of India.

In north-eastern region the tracts/areas with least biotic influence on the vegetation and annual rainfall ranging between 1500-4000 mm shows a remarkable bamboo diversity. For example, the studies by present author on bamboo diversity of North Cachar hills with a geographical area of *ca* 5000 km^2 reveal *ca* 20 species of bamboos out of 33 species reported from whole of Assam.

Biotic influence on the distribution : The biotic factors particularly the man-made have been responsible for limiting the distribution of bamboos in North-eastern region. Fangming (1988) mentions that

Table 4

States	Stations	Altitude (m) MSL	Temperature ax.	Temperature Min.	Rainfall (mm)	Relative humidity (%)
Assam	Dhubri	35 m	26.0	9.3	2,525.2	81
	Dibrugarh	106 m	27.7	6.9	2,759.4	83
	Guwahati	55 m	26.2	7.8	1,637.2	82
	Lumding	149 m	23.7	2.8	1,315 1	79
	Sibsagar	97 m	23.3	6 8	2,504.3	85
	Silcher	29 m	24.1	8.2	3,225.4	81
	Tezpur	79 m	23.7	8.4	1,894.4	81
Meghalaya	Cherrapunji	1313 m	1807	4.0	11,418.7	76
	Shillong	1500 m	17.2	−2.8	2,415.3	67
	Tura	370 m	22.5	8.7	3,361.6	80
Mizoram	Aizawl	1097 m	20.2	6.8	2,263.8	78
North Bengal (West Bengal)	Darjeeling	2127 m	13.9	−0.9	2,758.4	77
	Jalpaiguri	83 m	22.6	7.2	3,352.7	82
	Kalimpong	1209 m	18.0	4.5	2,262.3	81

(Based on India Meteorological Deptt. 1967).

the main limiting factor on distribution of bamboo is found to be deficiency of water due to destruction of forests, soil erosion and meagre soils. Bamboo forests are commonly distributed along the bank of streams, on the slopes and valleys, etc. In North-eastern India, the tribal people practise an ancient form of cultivation, which is locally known as 'jhum'. In this form of 'slash and burn' agriculture, the field is cultivated for a year or two before being left a fallow to allow natural regeneration of a forested cover. Ramakrishnan and Toky (1983) mention that originally, the cycle of '*jhum*' used to be *ca* 30 years. But the most common now is a cycle of about 4-5 years. On abandoned clearings due to '*jhum*' cultivation the bamboos cover extensive tracts to the exclusion of tree growth. This is particulary due to the extensive underground rhizome of bamboos for example *Dendrocalamus hamiltonii* and *Melocanna baccifera*. Due to successive short jhum cycles in the same sites even the rhizome of bamboos typical of the tracts or region are gradually eliminated. Shifting cultivation in bamboo rich areas of north-eastern region is quite prevalent. The record of bamboo diversity in Meghalaya indicates that 50% of species i.e. out of *ca* 40 are confined to the tracts—subjected to intensive jhum cultivation.

The tracts previously inaccessible and unexplored have opened out due to road building, shifting cultivation, industrialization, mining etc. and as a consequence the distribution and diversity of bamboos of the region is in a precarious state. The studies undertaken on the rarity of Indian bamboos by Bahadur and Jain (1983) and by the present worker on the species of N.E. region of the country reveal that over 10% of the species are rare and endangered. For example— *Arundinaria* 2, *Bambusa* 1, *Dendrocalamus* 1, *Dinochloa* 1, *Gigantochloa* 1, *Phyllostachys* 2, *Pleioblastus* 1, *Semiarundinaria* 1, *Sinobambusa* 1 (Table 5).

Phytogeographical affinity & distribution : Generally the pattern of distribution of different plant species of North-eastern region of India is such that the species of northern most part has the affinity to the taxa of North-western and Western China, whereas the southern and south-eastern part represent the Indo-Malesian (Table 1) and Burmese species. It is revealed that the states of Manipur, Nagaland, Mizoram, Meghalaya, Hill districts of Assam and foot hills of Arunachal Pradesh represent a high proportion of Indo-Malayan species of bamboo. It has been stated that the Himalaya has served primarily as a route of emigration and colonisation from the east

Table 5

Distribution of rare and endangered bamboos of North-eastern region.

Species	Distribution	Status
Arundinaria clarkei Hk. f.	Manipur, Sikkim	+++
Arundinaria mannii Gamble	Meghalaya (Amkasur in Jaintia Hills)	+
Bambusa mastersii Munro	Assam (Dibrugarh)	+++
Cephalostachyum capitatum Munro var. *decomposita* Gamble	Sikkim	+++
Dendrocalamus sahnii Naithani & Bahadur	Arunachal Pradesh (Subansiri District)	+++
Dinochloa maclellandii (Munro) Kurz	Assam (Lakhimpur)	+
Gigantochloa takserah Camus	Meghalaya (Garo Hills)	
Phyllostachys assamica Gamble ex Brandis	Arunachal Pradesh (Mishmi Hills)	+
Phyllostachys mannii Gamble	Nagaland	++
Pleioblatus simonii (Carr.) Nakai	Arunachal Pradesh (Tale Valley, Subansiri District)	+++
Semiarundinaria pantlingii Gamble	North Bengal, Arunachal Pradesh, Sikkim.	++
Sinobambusa elegans (Kurz) Nakai	Nagaland	++

Status :
+ Restricted to a very few localities or a single locality but found in fairly large numbers.
++ Found in small numbers but occuring in several areas.
+++ Occurring over a small geographic range.

and north-west, secondarily of endemic development (Stearn, 1960). North-eastern region being crescent-shaped due to the bending of Himalaya provided a meeting ground for Chinese, Sino-Japanese, Indo-Burmese and Malesian species which probably encouraged hybridization and thus has contributed to the richness of plant diversity of the region. *Ca* 30 species of bamboo typical of Burma extend their distribution into North-eastern part of India. Topographical features particularly the hilly terrain, deep valleys, slopes and river systems etc. have restricted the distribution of several species of bamboos in the region. Mohan Ram and Gopal (1981) while reporting the flowering of different bamboo species of Mizoram mention that the non-availability or insufficiency of pollen for cross pollination may result into poor seed production as in the case of *Dendrocalamus longispathus* and *Pseudostachyum polymorphum*. As a consequence of synchronous senescence of clumps following flowering and due to poor regeneration the distribution of the species may become isolated or narrowly confined.

North-eastern India is represented by Sino-Japanese elements such as *Phyllostachys*, *Pleioblastus*, *Semiarundinaria*, *Sinobambusa*, *Thamnocalamus*, *Chimonobambusa* in northern most part particularly in the Himalayan region. The Chinese mountains being much older in age, have considerable influence on the Himalayan flora (Hara, 1966). It is believed that during the tertiary period, a common flora must have covered the whole of Asia including Himalaya, China and Japan. In the present area of studies the bamboo species having affinity with the Sino-Japanese taxa are mainly confined to the eastern Himalaya covering different forest areas of Sikkim, West Bengal (North Bengal Himalaya) and Arunachal Pradesh, and also in various hilly ranges of Assam, Meghalaya, Mizoram and Manipur. Rau (1974) considers that the migration of floras, survival of the relicts, evolution of new species by an intermixing of different floras and acclimatisation of species from the lower altitudes must have all had a role in determining the present day composition and distribution of the Himalayan flora of high altitudes.

Systematic studies covering various aspects such as phytogeography, density, etc. of bamboos of India particularly of N.E. India are yet to be complemented. A thorough inventory on the occurrence of bamboos in the bamboo rich tracts for example, in North Cachar, Mikir, northern and southern forest tracts in district Cachar (Assam) and Burnihat Hills, Mishmi Hills, Abor Hills, Indo-Tibetan border, Patkai Boom (Arunachal Pradesh) and along the Indo-Burma border can reveal useful data on further extent, distribution and regeneration of bamboos in N.E. India. A statistical analysis on the distribution and diversity of bamboos of North-eastern region of India (Table 6) based on the accumulation of data from author's surveys in different tracts of the region, consultation of herbaria of Forest Research Institute. Lloyd Botanic Garden (Darjeeling) and Botanical Survey of India and perusal of literature reveal that in the states of Sikkim, West Bengal (North Bengal Himalaya), Arunachal Pradesh the number of genera-distributed ranges from 9-15 among 24-41 species; whereas in southern part of the region number of genera varies from 5 to 15 distributed among 10-32 species. The concentration of species in Arunachal, Meghalaya, Assam, North Bengal and Sikkim is quite remarkable with 41, 36, 33, 30 and 25 respectively. The State-wise distribution of genera, based on species diversity having more than three per genus indicate the dominance of *Arundinaria*, *Chimonobambusa* on higher altitude and *Bambusa*, *Dendrocalamus*, *Cephalostachyum* at lower elevations. The species of *Arundinaria*, *Chimonobambusa*, *Neouhouzeaua*, *Pseudostachyum*, *Thamnocalamus* etc. are disjunctly distributed in eastern Himalayan part of the area and Meghalaya, Mizoram. Nagaland and other hill tops of Assam.

The percentage of bamboo species typical of N E. Region distributed in other parts of India is very low (Table 7).

Table 6

Statistical analysis on the distribution and diversity of bamboos of N.E. region (*State-wise*).

States	Taxa	Main Genera (with > 3 spp.)
Arunachal Pradesh	No. of genera : 14 No. of species : 41	*Arundinaria, Burma, Cephalostachyum, Chimonobambusa, Dendroclamus.*
Assam	No. of genera : 13 No. of species : 33	*Bambusa, Dendrocalamus.*
Nagaland	No. of genera : 11 No. of species : 23	*Cephalostachyum, Dendroclamus.*
Manipur	No. of genera : 9 No. of species : 20	*Bambusa*
Mizoram	No. of genera : 7 No. of species : 15	*Bambusa, Dendrocalamus*
Meghalaya	No. of genera : 14 No. of species : 36	*Arundinaria, Bambusa. Chimonobambusa, Dendrocalamus.*
Sikkim	No. of genera : 10 No. of species : 26	*Arundinaria, Bambusa Chimonobambusa, Dendrocalamus, Thamnocalamus.*
North Bengal Himalaya (West Bengal)	No. of genera : 9 No. of species : 30	*Bambusa, Dendrocalamus.*
Tripura	No. of genera : 5 No. of species : 13	*Bambusa*

Total number of States : 9

Total number of species including 6 no. of cultigens : 71

Total number of genera : 19

Table 7

Indigenous species of N.E. Region distributed in other parts of India.

Species	Distribution
Bambusa arundinacea	Throughout India in the plains, common all over South India 30–1250.
B. balcooa	Bihar, Eastern U.P. (Gorakhpur).
B. nutans	Sub-Himalayan tract westwards to Yamuna.
B. tulda	Vishakhapatnam Distt. 450–600 m (Bahadur, 1979). Cultivated in plains and foot hills of N. India.
Cephalostachyum pergracile	Bihar, Madhya Pradesh and Andhra Pradesh.
Dendrocalamus hamiltonii	Westwards up to Garhwal Himalaya upto 1000 m.
Thamnocalamus falconeri	Westwards, throughout W. Himalaya.
T. spathiflorus	W. Himalaya.

Bambusa arundinacea, *B. balcooa* have wider distribution than other species. *Cephalostachyum capitatum*, a species occurring in Assam and Nagaland is distributed in parts of Bihar, Madhya Pradesh and Andhra Pradesh. Bahadur and Naithani (1976) believe that the range of distribution of this species from east to west and south-west in the hypothetical triangle of Bihar (Chhota Nagpur)—Andhra Pradesh (Kakinada)—Madhya Pradesh (Balaghat) has been gradual, uniform and possibly through the agency of rodents. *Thamnocalamus falconeri* Hk.f. ex Munro having its distribution in Sikkim, North Bengal Himalaya and Arunachal Pradesh extends its range upto Kumaon and Bhutan through Nepal. It is interesing to note here that Keng (1983) while assigning this species as *Himalayacalamus* i.e. *H. falconeri* (Hk.f.) Keng = *Thamnocalamus falconeri* Hk.f. ex Munro has referred the genus as 'monotypic and endemic' to Himalaya between 2300-3000 m. *Thamnocalamus spathiflorus* is distributed throughout Western Himalaya. *Chimonobambusa falcata* is found in W. Himalaya from Ravi to Nepal in E. Himalaya between 1200-2300 m. There is possibility of its occurrence in western most parts of Sikkim and Arunachal Pradesh. The distribution of *Dendrocalamus hamiltonii* further west in the foot hills of Garhwal Himalaya can be attributed to the climatic and edaphic factors.

Table 8 presents the distribution of bamboo species in different parts of north-eastern region. An analysis on the range of distribution of different species reveals an appreciable degree of similarity of species occurring in Sikkim—North Bengal Himalaya as mentioned below with that of Assam, Manipur, Meghalaya, Mizoram and Nagaland; 500-900 km away to south and south-east of the region.

Table 8

Distribution of various Bamboo species in North-eastern Region of India vis-a vis a check list

Species	Arunachal Pradesh	Assam	Nagaland	Manipur	Mizoram	Meghalaya	Sikkim	North Bengal	Tripura
1	2	3	4	5	6	7	8	9	10
Arundinaria clarkei	—	—	—	+	—	—	+	—	—
A. gracilis	+	—	—	—	—	—	+	+	—
A. hirsuta	—	—	+	—	—	+	—	—	—
A. kurzii	—	—	+	+	—	—	—	—	—
A. maling	+	—	—	—	—	—	+	+	—
A. mannii	—	—	—	—	—	+	—	—	—
A. microphylla	—	—	—	—	—	+	—	—	—
A. racemosa	+	—	—	—	—	—	+	+	—
A rolloana	—	—	+	—	—	—	—	—	—
A. suberecta	—	—	—	—	—	+	+	+	—
Bambusa arundinacea	+	+	—	—	+	+	+	+	+
B auriculata	—	+	—	—	—	—	—	—	—
B. balcooa	+	+	—	+	—	+	—	+	+
B. cacharensis	—	+	—	—	—	—	—	—	—
B. glauscescens = B. nana*	—	+	—	—	—	+	+	—	—
B. khasiana	—	+	+	+	—	+	+	—	—
B. kingiana	—	—	—	+	—	—	—	—	—
*B. lineata**	—	—	—	—	—	—	—	+	—
B. longispiculata	—	—	—	—	—	+	—	—	—
B. mastersii	—	+	—	—	—	—	—	—	—
B nutans	+	+	+	—	—	+	—	+	+
B. oliveriana	—	—	—	—	+	—	—	—	—
B. pallida	+	+	—	+	—	+	—	+	+
B. polymorpha	+	+	—	—	—	—	—	+	+
B. teres	+	+	—	—	—	—	—	—	—

(Contd...)

1	2	3	4	5	6	7	8	9	10
B. tulda	+	+	+	+	+	+	+	+	+
*B. vulgaris**	+	+	−	+	+	+	−	+	+
Cephalostachyum capitatum	+	−	+	−	+	+	+	+	−
var. *decompositum*	−	−	−	−	−	+	+	−	−
C. fuchsianum	+	−	+	+	−	−	−	+	−
C. latifolium	+	−	+	+	+	−	+	+	−
C. pallidum	+	−	−	+	−	+	−	−	−
C. peregracile	+	+	+	+	−	−	−	−	−
Chimonobambusa callosa	+	−	+	−	−	+	−	−	−
= *Arundinaria callosa*									
C. griffithiana = *A. griffithiana*	+	−	+	−	−	+	−	+	−
C. hookeriana	+	−	−	−	−	+	+	+	−
= *A. hookeriana*									
C. intermedia = *A. intermedia*	+	−	−	−	−	−	+	+	−
C. khasiana = *A. khasiana*	−	−	−	+	−	+	+	+	−
C polystachya	−	−	−	−	−	+	+	−	−
= *A. polystachya*									
Dendrocalamus calostachys	−	−	+	−	−	+	−	−	−
*D. giganteus**	+	+	+	+	+	−	+	+	−
D. hamiltonii	+	+	+	+	+	+	+	+	+
D. hookeri	+	−	+	−	+	+	+	+	−
D. longispathus	−	+	−	+	+	−	−	−	+
D membranaceous	+	−	−	−	−	−	−	+	−
D. patellaris	+	+	+	−	−	−	+	+	−
D. sahnii	+	−	−	−	−	−	−	−	−
D. sikkimensis	+	+	+	−	+	+	+	+	−
*D. strictus**	+	+	−	−	+	+	−	−	+
Dinochloa compactiflora	−	+	−	−	+	+	−	−	+
= *Melocalamus compactiflorus*									

(*Contd* ..)

1	2	3	4	5	6	7	8	9	10
D. maclellandii	−	+	−	−	−	−	−	−	−
Gigantochloa macrostachya	−	+	−	−	−	+	−	−	−
G. takeserah	−	−	−	−	−	+	−	−	−
Melocalamus indicus	−	+	−	+	−	−	−	−	−
Melocanna baccifera = *M. bambusoides*	+	+	+	+	+	+	+	−	+
M. humilis	−	+	−	−	−	−	−	−	−
Neohouzeoua dullooa	+	+	+	+	−	+	+	+	+
N. helferi	−	+	−	−	−	+	−	−	−
*Oxytenanthera albociliata**	+	+	−	−	−	+	−	−	−
O. nigrociliata	+	−	−	−	−	+	+	−	−
Phyllostachys assamica = *P. bambusoides sensu* Gamble.	+	+	−	−	−	−	−	−	−
P. mannii	−	−	+	−	−	+	−	−	−
Pleioblastus simonii	+	−	−	−	−	−	−	−	−
Pseudostachyum polymorphum	+	+	−	−	+	+	+	+	−
Semiarundinaria pantlingii = *Arundinaria pantlingii*	+	−	−	−	−	−	+	+	−
Sinobambusa elegans = *Arundinaria elegans*	−	−	+	−	−	−	−	−	−
Teinostachyum griffithii	+	+	+	+	−	+	−	−	−
Thamnocalamus aristatus = *Arundinaria aristata*	+	−	−	−	−	−	−	+	−
T. falconeri = *A. falconeri*	+	−	−	−	−	−	+	+	−
T. prainii = *A. prainii*	−	−	+	−	−	+	−	−	−
T. spathoflorus = *A. spathiflora*	+	−	−	−	−	−	−	+	−
*Thrysostachys oliveri**	+	+	−	−	−	−	−	−	−

* Introduced.

Species of Sikkim. North Bengal Himalaya distributed in other parts of north-eastern region (excluding cultigens)

Assam : *Bambusa arundinacea*, *B. khasiana*, (N.C Hills), *B. nutans*, *B pallida*, *B. tulda*, *Dendrocalamus hamiltonii*, *D. patellaris*, *D. sikkimensis* (N.C. Hills), *Neohouzeava dullooa* (N.C. Hills), *Pseudostachyum polymorphum* (N.C. Hills).

Nagaland : *Bambusa khasiana*, *B. tulda*, *Cephalostachyum capitatum*, *C. latifolium*, *Dendrocalamus hamiltonii*, *D. hookeri*, *D. patellaris*, *D. sikkimensis*, *Neohouzeaua dullooa*.

Manipur : *Arundinaria clarkei*, *Bambusa balcooa*, *B. khasiana*, *B. pallida*, *B. tulda*, *Cephalostachyum fuchsianum*, *C latifolium*, *Chimonobambusa khasiana*, *Dendrocalamus hamiltonii*.

Mizoram : *Bambusa arundinacea*, *B. tulda*, *Cephalostachyum capitatum*, *C. latifolium*, *Dendrocalamus hamiltonii*, *D hookeri*, *D. sikkimensis*, *Pseudostachyum polymorphum*.

Tripura : *Bambusa arundinacea*, *B. balcooa*, *B. nutans*, *B pallida*, *B. tulda*, *Dendrocalamus hamiltonii*, *Neohouzeaua dullooa*.

Meghalaya : *Arundinaria microphylla*, *A. suberecta*, *Bambusa arundinacea*, *B. balcooa*, *B. khasiana*, *B. pallida*, *B. tulda*, *Cephalostachyum capitatum*, *Chimonobambusa griffithiana*, *C. hookeriana*, *C. khasiana*, *C. polystachya*, *Dendrocalamus hamiltonii*, *D. hookeri*, *D. sikkimensis*, *Neohouzeaua dullooa*, *Oxytenanthera nigrociliata*, *Pseudostachyum polymorphum*.

The number and genetic diversity of bamboo taxa of Sikkim—North Bengal (E. Himalaya) disjunctly distributed in Meghalaya is higher than in any other part of the region. Following species show very restricted distribution :

Dendrocalamus sahnii	Arunachal Pradesh
Pleioblastus simonii	–do–
Arundinaria kingii	(Manipur)
Bambusa kingiana	–do–
Arundinaria mannii	(Meghalaya)
Gigantochloa tekeserah	–do–
A. rolloana	(Nagaland)
Sinobambusa elegans	–do–
Bambusa oliveriana	(Mizoram)
Bambusa cacharensis	(Assam)
B. mastersii	–do–
B. teres	–do–
Dinochloa maclellandii	–do–
Melocanna humilis	–do–

As stated earlier, until the tracts of north-eastern region, *Terra incognito*, floristically surveyed and the species are taxonomically worked out, it appears not possible at the state of present knowledge to refer a species as endemic with certainity.

Distribution of different species within the region reveals that *ca* 40 spp. are confined to north and north-western part of the region in Eastern Himalaya. Nearly 10% of the total bamboo species occur throughout the area. The genera *Bambusa* (17 spp.), *Arundinaria* (10 spp.), *Chimonobambusa* (6 spp.) and *Dendrocalamus* (10 spp.) represent genetic and species diversity. *Pseudostachyum*, *Himalayacalamus sensu* Keng=(*Thamnocalamus falconeri*) and *Melocalamus* are monotypic genera distributed in the region. The species occurring in the southern and south-eastern part of the region show affinity to the Indo-Malaysian and Indo-Burmese species while the species of northern and north-eastern areas have the resemblance with Sino-Japanese and Indo-Chinese species.

SUMMARY

North-eastern region of India comprising the States of Sikkim, West Bengal (North Bengal Himalaya), Arunachal, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura has over 50% of bamboo species of the total species from India i.e. *ca.* **115. The principal genera are :** *Arundinaria, Bambusa, Cephalostachyum, Chimonobambusa, Dendrocalamus, Dinochloa, Melocanna* **and** *Thamnocalamus* **etc. The region can be referred as the centre of genetic diversity for the genera;** *Arundinaria, Bambusa, Cephalostachyum* **and** *Dendrocalamus.* **The present studies based on surveys in different parts of north-eastern region reveal useful information on distributional patterns of bamboos within the region and role of attributing factors such as morphological features, altitudinal variation, soil types, rainfall, temperature and biotic influence, etc. Statistical analysis on the dominance of bamboo taxa in different parts of the region is provided.**

भारत के उत्तर-पूर्वी क्षेत्र के बाँसों के वितरण का अध्ययन

सास० विश्वास

सारांश

भारत के उत्तर-पूर्वी क्षेत्र में जिसमें सिक्किम, पश्चिमी बंगाल (उत्तरी बंगाल का हिमालय क्षेत्र), अरुणाचल प्रदेश, असम, मणिपुर, मेघालय, मिजोरम, नागालैन्ड और त्रिपुरा राज्य आते हैं, भारत की सम्पूर्ण बाँस जातियों की 50% से अधिक जातियां, अर्थात लगभग 115 जातियाँ पाई जाती हैं। इस क्षेत्र की प्रमुख प्रजातियाँ अरुण्डिनेरिया, बैम्बूसा, सिफैलोस्टैक्युम, किमोनोबैम्बूसा, डेंड्रोकैलेमस, डायनोक्लोआ, मेलोकेन्ना और थैम्नोकैलेमस आदि हैं। यह क्षेत्र अरुण्डिनेरिया, बैम्बूसा, सिफैलोस्टैक्युम और डेंड्रोकैलेमस प्रजातियों की अनुवांशिकीय विभिन्नताओं का केन्द्र भी माना जा सकता है। प्रस्तुत अध्ययन जो उत्तर-पूर्वी क्षेत्र के विभिन्न भागों में किये गए सर्वेक्षणों पर आधारित हैं, इस क्षेत्र के भीतर बाँसों की वितरण सज्जा के बारे में उपयोगी जानकारी देता तथा वह उसके रचनाकारीय लक्षण, ऊंचाई गत विभिन्नताए आना, मृदा प्रकार, वर्षा, तापमान और जैव प्रभाव आदि कारकों की भूमिकाए भी समझाता है। इस क्षेत्र के विभिन्न भागों में बाँसों की विभिन्न प्रजातियों–जातियों की प्रमुखता का साँख्यिकीय विश्लेषण भी दिया गया है।

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GREGARIOUS FLOWERING IN *DENDROCALAMUS STRICTUS* IN SHAHDOL (MADHYA PRADESH)—SOME MANAGEMENT CONSIDERATIONS

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Introduction

Common bamooo (*Dendrocalamus strictus*) occurs in deciduous forests all over India except in North Bengal, Assam and moist regions of west coast (Troup, 1921; Varmah and Bahadur, 1980). In Madhya Pradesh it occurs as an understorey in teak, sal and mixed deciduous forest types covering an area of about 1.83 million ha (Dutta and Tomar, 1964; Anon, 1967). The districts which are rich in bamboo forests, include, Balaghat, Bastar, Bilaspur, Mandla, Hoshangabad, Betul, Raipur, Shahdol, Sidhi, Panna, etc. In Shahdol it occurs in North Shahdol and Umaria Forest Divisions in an area of about 42500 ha.

Dendrocalamus strictus has two kinds of flowering behaviour, (a) sporadic and irregular flowering and (b) periodical gregarious flowering (Brandis 1906; McClure, 1966). Sporadic flowering takes place in isolated clumps and only a few culms flower. The culm which flowers may or may not die. Sporadic flowering in *Dendrocalamus strictus* takes place almost every alternate year practically in all bamboo areas during November to May. Important characteristics of sporadic flowering are : (i) scattered nature of flowering, only few clumps are involved in flowering, (ii) only a few culms flower in a clump, (iii) the culms may or may not die after flowering, (iv) the clump does not die, and (v) usually it takes place irregularly almost every alternate years.

Gregarious flowering in *Dendrocalamus strictus* is a recognised phenomenon. The characteristics of gregarious flowering are : (i) flowering occurs almost in the entire area, (ii) it involves almost all or some proportion of clumps, (iii) flowering takes place in all the culms in a clump, (iv) flowering is followed by the death of the clump, (v) it follows a cycle which occurs after a long interval, (vi) it progresses in a definite direction like an epidemic wave beginning at one definite edge of an area, and (vii) it takes a few years, commonly 2 to 4 years to complete flowering in the area. The period between two gregarious flowerings over the same area is believed to be somewhat constant and is called physiological cycle. Different periods for physiological cycle have been reported for different areas. Clements (1956) reported that *Dendrocalamus strictus* was introduced in Cuba from 1912 seeeding in Garhwal (Uttar Pradesh) and it flowered in 1956, indicating a cycle of 44 years. Wong and Chen (1971) reported that a plantation raised in Taiwan in 1912 from seeds from Bihar (India) flowered in 1969, showing a physiological cycle of 57 years. Plantation of *Dendrocalamus strictus* raised in Forest Research Institute (FRI), Dehra Dun, during 1937 flowered during 1987 indicating a cycle of 50 years. Similarly different workers have reported different physiological cycles ranging from 20 years to 100 years for different areas (Kurz, 1875; Deogan, 1936; Mathauda, 1952; Varmah and Bahadur, 1980; Suri and Chauhan, 1984; Chaturvedi, 1986).

In Shahdol area gregarious flowering took place during 1984 and it continued upto 1987. There is no available record for previous gregarious flowering in this area. Enquiry from older persons indicated that such flowering took place almost 75 years ago.

In natural *Dendrocalamus strictus* forests of Madhya Pradesh, some records of gregarious flowering are available. The available information on gregarious flowering in Madhya Pradesh is summarised in Table 1 (Dutta and Tomar, 1964; Anon, 1967; Prasad, 1986).

It would be thus clear from the Table 1 that period of gregarious flowering varies from 20 years to 75 years depending upon locality, management practices, biotic interferences, etc. Several reasons have been put forward to explain the process of gregarious flowering. Kawamura (1927) believed that gregarious flowering is related with life cycle of the bamboo. Storage of large quantity of starch, sugar and other substances in the clumps tend to help flowering (Gamble, 1896; Dutta and Tomar, 1964).

Similarly, some workers have tried to relate gregarious flowering with injury, nutrition, climatic conditions, genetical constitution, soil factors, etc. (Nicholson, 1922; Patil and Panchal, 1980; Hussain, 1980).

Factors affecting gregarious flowering

Observations taken in Shahdol area indicate that following factors affect the intensity of gregarious flowering :

(a) Age of the crop
(b) Site quality
(c) Management practices
(d) Biotic interferences.

(a) *Age of the crop* : For gregarious flowering it is often believed that period of gregarious flowering of the clump depends upon age of the clump. Only those clumps flower and subsequently die which have attained the age of physiological maturity. In natural forests of bamboo which are worked under selection system, it would be wrong to presume that most of the clumps belong to the same age. In good forests, there must be a continuous formation of clumps and clumps of all age classes must be present as sufficient seeds are available from sporadic flowering. If that is the case then only those clumps should flower and die which have reached near the age of physiological maturity and the gregarious flowering should effect only a small proportion of the clump population. Another plausible explanation which can be given is that most crops are made of seeds obtained during the previous gregarious flowering. In that case it is logical to conclude that most clumps are of the same age. More definite information would be available in near future from plantations. The plantations 12 to 14 years of age which adjoined natural forest

Table 1

Records of gregarious flowering in Madhya Pradesh

Area/Forest Division	Periods of gregarious flowering			Physiological cycle (year)
	1st	IInd	IIIrd	
Balaghat (North & South)	1916	1963	—	47.0
Bastar (South)	1948	1981	—	33.0
Betul	1940	1968	—	28.0
Bilaspur and Bilaspur North	1895	1960	—	65.0
Harda	1942	1976	—	34 0
Jabalpur	1930	1965	1985	27.5
Khandwa (North & South)	1910	1954	—	44.0
Mandla (South)	1900	1921	1946	23.0
Mandla (North)	1930	1967	—	37.0
Raipur	1924	1960	—	36.0
Seoni	1921	1939	1964	21.5
Seoni South	1922	1964	—	42.0
Shahdol (Umaria)	1909	1984	—	75.0

did not show sign of gregarious flowering.

(b) *Site quality*: Observations in Shahdol Circle (Madhya Pradesh) indicate that site quality has considerable affect on the bamboo flowering. In the same area, good sites tend to delay and decrease the extent of gregarious flowering. Observations taken in 55 plots randomly selected in five felling series indicate the following results (Table 2).

Table 2

Period and extent of gregarious flowering in Shahdol Circle

Forest Division	Felling Series	No. of Plots	Quality of Bamboo	Year of flowering	%age of flowerd clumps
North Shahdol	1. Ghunghuti	10	III	1984	81
	2. Machheha	5	I	Not flowered upto 1987	—
	3. Beohari	10	III	1984	90
Umaria	1. Salkania	10	I	1985	51
	2. Pator	10	II	1984	60

(c) *Management practices* : In areas where clumps are properly worked the proportion of flowered clumps is comparatively less while in area with unworked and congested clumps, the proportion of flowered clumps is more (Table 3).

(d) *Biotic interferences* : Biotic interferences such as, grazing and fire, increase the intensity of gregarious flowering. The bamboo forests located near village have greater flowering intensity, while those located in comparatively protected areas away from habitation flowered partially. The areas with heavy biotic interference coupled with poor site quality lead to almost hundred per cent flowering and death of plants. This may be due to the fact that areas subjected to heavy biotic pressure did not have younger crop. Most of the existing crop consisted of malformed and degraded clumps. There was almost complete absence of younger clumps.

Management considerations

Gregarious flowering in bamboos has tremendous impact on the management of bamboo forests. The points needing attention are :

(a) Seed collection.
(b) Rescheduling felling operation.
(c) Protection of natural regeneration.
(d) Creation of rhizome bank and artificial regeneration.

(a) *Seed collection* : Bamboo is commercially and socially important species. It is being planted on a large scale in different States. Usually there is a great demand for bamboo seeds from several sectors. It is, therefore, necessary to collect as much seed as possible after assessing requirement. The seeds would need proper storage for longer viability.

Seed production potential in Shahdol area was assessed by State Forest Research Instiute, Jabalpur. Prasad (1986) reported that average seed production in gregariously flowered area varied from 0.9 tonne to 1.5 tonne per ha. Even taking a value of 0.6 tonne per ha total seed production was about 25,000 tonnes. Out of this, about one-third to one-fourth quantity of seed could have been collected. But only about 100 tonnes of seed was collected during 1985 and 1986, though more was available and could not be purchased due to paucity of funds.

(b) *Rescheduling felling operations* : After gregarious flowering clumps die. These clumps need to be harvested as early as possible. Delay in harvesting may results in loss due to rotting and fire. Experience in

Table 3

Flowering in congested and uncongested clumps in Ghunghuti felling series

Category	Number of clumps	Clumps flowered	%age
Congested clumps	150	148	99
Uncongested clumps	180	114	63

Shahdol Circle indicates that where annual harvest from bamboo forest was about 10,000 tonnes during normal years, about 1,00,000 tonnes was available for harvesting during 1985 due to gregarious flowering. This necessitated rescheduling felling operation. The whole quantity was removed in two years i.e. 60,000 tonnes in 1985–86 and 40,000 tonnes in 1986–87. The operation required; (i) more budget allocation for harvesting, (ii) more labour force, (iii) additional organisation, (iv) additional support for transport, (v) more number of depots, etc. and (vi) arrangement for sale and additional supplies to paper mills, etc.

Depending upon the felling cycle one-third or one-fourth coupes are due for normal working as per working plan prescriptions. Since yields are increased several times due to harvesting of dried bamboo, decision is necessary about the working in coupes due in that year. It is better to work only flowered clumps otherwise future yield would be considerably affected.

(c) *Regeneration of bamboo areas* : Protection of regeneration of bamboo in flowered area is perhaps the most important operation because it will decide whether bamboo forests will again appear in the area or they are being permanently dessipated. Since abundant seed is available near the flowered clump, sufficient regeneration usually springs up in the area except in areas where soil is deficient or soil surface is too hard. In most places seedling regeneration comes up in larger number, several times more than required.

Grazing and fire are most detrimental to seedling regeneration. Therefore, area needs protection from grazing and fire. Due to grazing pressure and other socio-political problems it was not possible to close entire area from grazing. But with persuation and discussion with local people, in Shahdol, it was decided to close half of the area in each felling series for grazing. Cattleproof trenches were dug, the closed areas were notified. Additional organization in form of grazing watchers and fire-watchers were deployed and effective protection was ensured

Regeneration assessment was done in protected and unportected areas in some felling series in 1986 and in 1987 during the month of May-June which indicated that sufficient regeneration existed in protected area (Table 4).

It would be clear that in unprotected areas regeneration is generally poor although slightly higher on better sites. The seedlings existed only in places where some physical and mehanical obstruction was provided by stones and boulders, bamboo stumps, lops and tops, etc. These are likely to be grazed and browsed in coming years On the other hand in protected areas it is expected that enough seedlings exist to regenerate the area. Protection of the area for at least 6 to 7 years appears essential. When protection against grazing and fire is not provided, the regeneration in form of seedlings are grazed/browsed and killed but rhizome remains alive for some period. Experience in some areas e.g. Mandla and Betul (both in Madhya Pradesh) indicates that even if protection is provided after 5 years of gregarious flowering, the regeneration could be revived to some extent.

(d) *Creation of rhizome bank and artificial regeneration of areas with deficient regene-*

ration : New nurseries need to be established and existing nurseries may be expanded to create a large rhizome bank to cater the plantation needs for a few years. This is necessary to undertake plantation of bamboo in areas where natural regeneration is deficient. This is necessary with view to utilizing existing seeds properly and to revive the bamboo forests where natural regeneration fails due to adverse factors.

Table 4

Regeneration count in protected and unprotected area.

Felling series	Number of plots (10 m×10 m)	Average number of seedlings			
		1986		1987	
		Protected	Unprotected	Protected	Unrotected
Ghunghuti	10	650	26	150	3.0
Beohari	10	450	31	126	4.5
Salkania	10	1550	46	700	4.0
Pator	10	1050	51	320	3.0

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SUMMARY

Gregarious flowering in *Dendrocalamus strictus* is recognised phenomenon which occurs periodically after a period of 25 to 100 years. The periodicity and intensity of flowering depends upon age of clumps, site factors, location, management practices and biotic interferences. Gregarious flowering in bamboo occurred in Shahdol Circle (Madhya Pradesh) during 1984-87 where the author worked as Conservator of Forests. Observation on the intensity of gregarious flowering is found to be associated with age, site quality, management practices and biotic interferences. Certain management considerations necessitated due to gregarious flowering such as; seed collection, rescheduling felling operation, protection of the area, creation of rhizome bank and artificial regeneration, etc. are discussed in this paper.

सहडोल (मध्य प्रदेश) में डेंड्रोकैलेमस स्ट्रिक्टस का सामूहिक पुष्पन-प्रबन्ध की कुछ विचारणीय बातें

ए०पी० द्विवेदी

सारांश

डेड्रोकैलेमस स्ट्रिक्टस में सामूहिक पुष्पन होना भली-भांति ज्ञात घटना है जो 25 से 100 वर्षों की अवधि के उपरान्त समय-समय पर होती रहती है। पुष्पन की अवधि और चण्डता बोडों की उम्र, स्थल कारक, स्थिति, प्रबन्ध प्रक्रियाए और जैव हस्तक्षेप पर निर्भर हैं। बांसों का सामूहिक पुष्पन शहडोल वृत (मध्य प्रदेश)

में 1984-87 में हुआ जहां इन पंक्तियों का लेखक वनसंरक्षक पद पर कार्य नियुक्त था। सामूहिक पुष्पन की चण्डता पर किये गये पर्यवेक्षण उसकी उम्र, स्थल गुण, प्रबन्ध प्रक्रियाओं और जैव हस्तक्षेप से सम्बद्ध किये हुए पाये जाते हैं। सामूहिक पुष्पन के कारण आवश्यक बनी प्रबन्ध की कुछ बातों जैसे बीज सग्रह, पातन चक्रो का पुर्निधारण, क्षेत्र की सुरक्षा करना, शिफास्तम्भ सग्रह बनाना और कृत्रिम पुनर्जनन आदि का विवेचन प्रस्तुत अभिपत्र में किया गया है।

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GENETIC RESOURCES OF BAMBOOS—AN INDIAN PERSPECTIVE

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Introduction

Bamboos, a group of tall arborescent grasses, have intimately been associated with mankind since ancient times. This group provides basic necessities of life i.e. fuel, food, shelter and clothing, particularly to the rural people, and is also a source of raw material for cottage industry besides their diversified usage in paper industry. Thus, bamboos have played an immense role in the socio-economic development, particularly of the rural/native communities in the areas of their preponderance.

India is endowed with a large number of bamboo species and is perhaps having the world's largest reserves of bamboos. The large gene pool of species diversity coupled with their wide occurrence in the Indian sub-continent has put on this group the pressure of human selection for utilisation for day-to-day needs. The utilities of some of the genera, whether industrial or otherwise, are so much that many bamboo species are being cultivated to meet their growing demand. In view of the economic potential of this group, this paper examines the distribution and diversity of different bamboos taxa in Indian context. The overall bamboo genetic resources scenario in the country is discussed to take stock of existing national resources in this group, to meet the increasing demand for exploitation of economically useful species and for their conservation *in situ*. The paper gives in short, an overview of the bamboo genetic resources in the Indian context.

Floristic Richness

Sharma (1980) has reported about 75 genera and 1250 species distributed in different parts of the world, mostly confined to south-east Asia. This group mainly inhabits the humid tropical/sub-tropical regions, and Asia and America account for the maximum species richness (Anon, 1948) containing 320 and 179 species respectively. India has rich diversity of bamboo genetic resources. Whereas Bahadur and Jain (1983) have reported 113 species of bamboo belonging to 200 genera distributed in India, Sharma (1980) reports nearly 136 species. Almost 50% of the species diversity finds its ecological niche in North-eastern India.

Out of 22 genera distributed in India, nineteen (19) are indigenous and three (3) are exotic, introduced for cultivation. The indigenous genera of bamboo in India are *Arundinaria*, *Bambusa*, *Cephalostachyum*, *Chimonobambusa*, *Dendrocalamus*, *Dinochloa*, *Gigantochloa*, *Indocalamus*, *Melocanna*, *Neohouzeaqa*, *Ochlandra*, *Oxytenanthera*, *Phyllostachys*, *Pseudostachyam*, *Schizostachyum*, *Semiarundinaria*, *Sinobambusa*, *Teinostachyum*, and *Thyrsostachys tachys*. The three exotic genera *Guadua*, *Pseudosasa* and *Thyrsostachys* are only occasionally found in cultivation. However, Guadua has since been merged with *Bambusa* (Bahadur and Jain, 1983).

Diversity in Life form/Habit

Bamboos also differ widely in stature and form. For example, *Dendrocalamus strictus* is usually about 30 m tall while *Arundinarias* are only shrubby Others such as *Teinostachyum helferi*, *Arundinaria prainii* and *Caphalostachyum capitatum* are stragglers and *Melocalamus compactiflorus* and *Schizostachyum* spp., the so-called climbing bamboos are slender, scandent climbers stretching over the crowns of tall forest trees. Others like *Pseudostachyum polymorphum* (Eastern Himalayas), *Melocanna bambusiodes* and *Bambusa nutans* (north-eastern region) have a creeping habit. A few froms such as *Microbambusa macrostachys* and *Atractocarpa olyriformis* (occurring in the Cameroons) are herbaceous.

Diversity in culms structure

The bamboos are characterised by woody pointed stems, commonly called 'culms', arising from their rhizomes, which are also woody and densely clustered so that culms grow in clumps. In some cases, they grow at intervals from a long creeping rhizome (*Melocanna*) or in tufts consisting of a small number of clumps (*Phyllotachys*).

Culms are generally round and smooth, when they are hollow (the female bamboos) they have transverse septa at the nodes. In other cases culms are solid (the 'male bamboos') like in *Arundinaria prainii*, *Dendrocalamus strictus* and *Oxytenanthera stocksii*. Culms are jointed at intervals and have prominent ring bearing sheaths characteristic of each species.

In general, culms do not bear any branches for a considerable height above the base. However, in culms of *Dendrocalamus hamiltonii* and *Oxytenanthera albociliata*, very large and prominent branches are found. *Bambusa arundinacea* and *B. tulda* also have branchlets, but they are arranged alternatively in dense clusters. In case of *B. arundinacea* and *B. blumeana*, the lateral branches and the circle of false rootlets at the lower nodes harden into spines, giving a natural armour to clumps.

Diversity in growth, phenology and size

Bamboos, in general, flower only once during their life time and die out soon after. Flowering usually takes place at intervals of 25-50 years, but exceptions like *Schizostachyum elegantissimum*, *Arundinaria wightiana*, *Bambusa lineata* and *Ochlandra rheedii* flower every third year. Almost all the clumps from a particular stock flower simultaneousl', which is the reason that clumps from different stock of the same species or different species are grown together to make for constant supply of bamboos. The range of growth in bamboos culms also varies between about 5 cm per day to 40 cm a day as in *Dendrocalamus giganteus* It is said that bamboos may be the world's fastest growing plants. The Japanese have recorded growth of more than 1 m in 24 hours. Some of the variants reach height of more than 30 m and their hollow stems approach about 30 cm in diameter.

Distribution in India

In the Indian sub-continent, bamboos are important dominant component of tropical and sub-tropical moist deciduous and occasionally semi-evergreen forests. They thrive best and form rich belts of vegetation in the well-drained parts of monsoon forests at the foot of Himalayas and in the peninsular ghat region. However, very few species occur in the Himalayas, and they are largely concentrated in north-eastern region, the western ghats and the Andamans and in the adjacent region in Burma, China, Bangladesh and Sri Lanka. Indian diversity is confined largely in the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkin, Tripura and West Bengal. Besides this, promising diversity also occurs in Andamans & Nicobar Islands and in Bastar region of Madhya Pradesh, hills and *tarai* (foot hills) region of Uttar Pradesh, Bihar, Orissa and in the eastern & western ghats. Regionwise occurrence of bamboo diversity in India is given in Table 1. They cover nearly ten million hectares of India's forest areas with a production of about 3.2 million tonnes per annum (Vermah and Bahadur, 1980).

Table 1

Region-wise species diversity in Indian Bamboos

Region	Genera (No)	Species (No.)	Diversity represented
1. North-eastern India	16	58	*Arundinaria* (9), *Bambusa* (12), *Cephalostachyum* (5), *Chimonobambusa* (6), *Dendrocalamus* (7), *Dinochloa* (2), *Melocanna* (1), *Neohouzeaua* (2), *Oxytenanthera* (2), *Phyllostachys* (2), *Pseudostachyum* (1), *Semiarundinaria* (1), *Sinobambusa* (1), *Teinostachyum* (1), *Thamnocalamus* (4).
2. North-western India	5	14	*Bambusa* (4), *Chimonobambusa* (2), *Dendrocalamus* (4), *Phyllostachys* (2), *Thamnocalamus* (2).
3. Indo-Gangetic Plains	4	8	*Bambusa* (4), *Cephalostachyum* (1) *Dendrocalamus* (2), *Oxytenanthera* (1).
4. Peninsular/South India (Eastern & Western Ghats).	8	24	*Bambusa* (3), *Cephalostachyum* (1), *Chimonobambusa* (1), *Dendrocalamus* (1) *Indocalamus* (3), *Ochlandra* (9), *Oxytenanthera* (5), *Tainostachyum* (1).
5. Andaman & Nicobar Islands	6	7	*Bambusa* (2), *Cephalostachyum* (1), *Denerocalamus* (1), *Dinochloa* (1), *Oxytenanthera* (1), *Schizostachyum* (1).

Source : Thomas *et al.*, 1985.

Many bamboo species are curiously species-specific growing in association with other species in natural habit. For example, *Bambusa tulda* grows with another bamboo *Cephalostachyms pergracile* in moist parts of Bengal and Pegu (Burma) or with *Dendrocalamus strictus* in drier parts of Bengal and Assam. Also *Bambusa polymorpha*, which is common in upper mixed forests of Martaban and Pegu Yomas (Burma), grows with teak in Assam and Bangladesh.

Economic Uses/Cultivation

Bamboos form an essential component in cottage and rual industry in Asia and pacific region. The quality of fast regeneration, strong, straight, smooth, light and hard wood, easy to split and cut and easy transportability has led to their multifarious uses in rural areas as given in Table 2. It may be visualised from the table that the diverse ethnic uses of bamboo in the rural areas make it useful to the villagers in almost every need of life. Not only this, bamboo has also found some specialised uses. For example, the Monpas of Assam build suspension bridges with bamboo, and in Bihar, it is replacing steel in Tubewell pipes because it is cheaper, rust free and more durable. Also, Viklang Kendra, a rehabilitation centre for the handicapped in Allahabad, U.P. has even made artificial limbs from bamboo. These are found to be lighter and cheaper than conventional prostheses. Its uses as food (pickled or stewed bamboo shoots are regarded as delicacies in some parts of the country, fleshy fruits of 'muli'—*Melocanna bambusoides*—bamboo of Assam, are eaten raw or cooked,—its seeds are eaten by people as a substitute for rice) and in medicine ('tabasheer' or 'banslochan', a fine siliceous matter found in the stem of many bamboo species like *Bambusa arundinacea*, *Melocanna bambusoides* and *Phyllostachys bambusoides*, is used in the ayurvedic drugs to treat cough and asthma) are also quite popular. Even more new uses are found in India. Scientists at the Forest Research Institute, Dehra Dun are working on bamboo reinforced cement concrete and the extraction of diesel fuel from the plant's many-jointed stem (Simmons, 1988).

However, truly commercially/exploited species of economic bamboo are few. Important among these are, *Bambusa arundinacea*, *B. balcoa*, *B. polymorpha*, *B. tulda*, *B. vulgaris*, *B. nutans*, *Dendrocalamus brandsii*, *D. hamiltonii*, *D. strictus*, *Melocanna baccifera*, *Ochlandra scriptoria*, *O. ebracteata*, and *O. travancorica* (Haque, 1984), and their major use remains in paper and rayon industry. Approximately 20 lakh tonnes of bamboo are at present being utilised for paper in India, leading to a production of nearly 6,00,000 tonnes of paper pulp every year (Vermah and Bahadur, 1980). In Asia, India is the largest consumer of bamboos for the manufacture of paper. Most paper mills operating in the bamboo growing areas of the country, are dependent wholly or partly on bamboo. Inspite of modernisation in industry, demand of bamboos is increasing. There has been constant efforts of increasing area under bamboo cultivation to meet current demands.

Genetic Erosion/Conservation needs

Bamboo resources are being depleted fast in the region due to increasing demands and consequent overcutting. The demand is being met by making the felling cycles shorter in the shifting cultivation systems, largely prevalent in the bamboo rich areas.

Table 2

General economic use of Bamboos in India.

Usage	Species
1	2
Constructions	*Bambusa polymorpha, B. balcooa, B. tulda, B. arundinacea, B nutans, B. blumeana, Cephalostachyum pergracile, Dendrocalamus membranous, D. hamiltonii, D. giganteus, D. longispathus, D. strictus, Ginantochloa nigrociliata, Melocanna baccifera, Neohouzeaua dullooa, Teinostachyum beddomei.*
Thatching and Roofing	*Bambusa arundinacea, B. tulda, B. polymorpha, Dendrocalamus strictus, Chimonobambusa falcata, Oxytenanthera monoadelpha.*
Walling of native huts	*Sinobambusa elegans.*
Lance staves	*Dendrocalamus strictus, Ochlandra travancorica, O. scriptoria.*
Tea estates	*Pseudostachyum polymorphum.*
Walking sticks	*Arundinaria armata, Dendrocalamus strictus.*
Basket making	*Arundinaria intermedia, Bambusa nutans, B. pallida, B. arundinacea, B. khasiana, Chimonobambusa falcata, Dendrocalamus longispathus, Indocalamus wightiana, Neohouzeaua helferi, Neohouzeaua dulloa, Oxytenanthera ritcheyi, Thamnocalamus spathiflorus.*
Bows and arrows	*Bambusa arundinacea, Cephalostachyum cepitatum, Dendrocalamus strictus.*
Cooking utensils	*Cephalostachyum pergracile.*
Mats	*Arundinaria intermedia, Bambusa nutans, B. terea, B. tulda, B. pallida, B. arundinacea, B blumeana, B. hamiltonii, Indocalamus wightianus, Teinostachyum dullooa.*
Hedges	*Bambusa nana, Dendrocalamus giganteus.*

(*Contd...*)

1	2
Water containers crops etc.	*Bambusa pallida*, *Dendrocalamus sikkimensis*, *D. giganteus*, *D. hookeri*.
Agricultural implements	*Dendrocalamus strictus*, *Ochlandra travancorica*, All thinner varieties.
Seed food	*Bambusa arundinacea*, *Cephalostachyum pergracile*, *Dendrocalamus strictus*.
Furniture	*Dendrocalamus strictus*.
Fodder	*Arundinaria racemosa*, *Chimnobambusa densifolia*, *Cephalostachyum pergracile*, *Dendrocalamus strictus*, *D. sikkimensis*.
Floats for timber; rafts	*Bambusa arundinacea*, *Dendrocalamus*, *hamiltonii*, *Ochlandra scriptoria*.
Fencing	*Indocalamus wightianus*, All bamboos.
Tool handles	*Dendrocalamus strictus*, *Ochlandra travancorica*.
Fishing rods	*Arundinaria amabilis*, *Chimonobambusa falcata*, *C. khasiana*, *C. intermedia*, *Dendrocalamus strictus*.
Hookah pipes	*Chimonobambusa falcata*, *Themnocalamus spathiflorus*.
Shooli for food	*Bambusa tulda*. *B. arundinacea*, *Dendrocalamus giganteus*, *Sinobambusa elegans*.
Punting poles	*Oxytenanthera stocksii*.
Sericultural industry	*Bambusa arundinacea*, *Dendrocalamus strictus*.
Chicks for doors and windows	*Bambusa arundinacea*, *Dendrocalamus strictus*.
Pipes	*Teinostachyum griffithii*.
General utility	*Bambusa arundinacea*, *Dendrocalamus strictus*, *D. hookeri*.
Pipes	*Teinostachyum griffithii*.

(*Contd...*)

1	2
General utility	*Bambusa arundinacea, Dendrocalamus strictus, D. hookeri.*
Haystack stabilizers	*Dendrocalamus strictus.*
Horticultural pursuits	*Bambusa arundinacea, Dendrocalamus strictus.*
Cremation, coffins	*Bambusa arundinacea, Dendrocalamus strictus*
Cradles	*Bambusa arundinacea, Dendrocalamus strictus*
Scaffolding	*Bambusa arundinacea, Dendrocalamus strictus*
Cartyokes	All large sized hard and solid bamboos
Ladders	*Bambusa arundinacea, Dendrocalamus strictus.*
Musical instruments	*Dendrocalamus strictus. Arundinaria* sp.
Protection during grain pounding	*Bambusa arundinacea* and all large sized bamboos.
Country tiles	*Bambusa arundinacea.*
Stakes for foresters	All bamboos.
Cartsheds & roofs	All bamboos.
Pan trays	*Neohozeaua dullooa.*
Seed drills	*Bendrocalamus strictus.*
Containers for administering medicines to animals	*Bambusa arundinacea.*
Ornaments	*Bambusa vulgaris, Cephalostachyum pergracile.*
Boat roofs	*Bambusa arundinacea.*
Pea sticks	*Thamnocalamus spathiflora.*
Trellises	*Bambusa arundinacea, B. blumeana.*
Afforestation of river banks soil conservation and shelter belt and wind trees.	All bamboos.

As a result, our native resources are greatly threatened. Bahadur and Jain (1983) have indentified some of the rare, and as such, threatened species by studying the material preserved in the herbarium of Forest Research Institute, Dehra Dun, which has one of the finest collections of bamboos in Asia. They have indentified *ca* 26 species/varieties or roughly 25% taxa of the Indian resources as rare/endemic, and have classified them into three basic categories : (i) Those restricted to very few localities or a single locality but found in fairly large numbers, (ii) those found in small numbers but occurring in several areas, and (iii) those occurring as a very few individuals over a small geographic range.

The third category is, definitely, truly endemic and therefore, highly threatened.

This indicates the immediate attention required for their conservation.

Conservation of bamboo genetic resources is particularly important because flowering, in most cases is irregular and uncertain. Therefore, both *in situ* and *ex situ* conservation is desirable. *In situ* conservation required declaration of some specific bamboo rich pockets in north-eastern region and the western ghats as reserved bamboo sanctuaries. For *ex situ* conservation, there is urgent need to augment studies on conservation of bamboo species and variants through tissue culture technique, and also of faster propagation of specially rare bamboo species through tissue culture generated plant material.

Future thrust

The depleting genetic resources in bamboos would call for an immediate need for their overall study and management, particularly their cataloguing. An inventory prepared, as such, would be of great help in keeping stock of this vital group of plants. This will involve collection of, germplasm, their evaluation and documentation, and finally utilisation of selected germplasm. A small beginning has been made regarding this under the aegis of All India Coordinated Research Programme on Under-utilised and Under-exploited plants at its coordinating centre, Basar (Arunachal Pradesh), and a survey and collection of germplasm from Arunachal Pradesh and Meghalaya has been initiated. The material so collected is being evaluated at this centre through a set of defined descriptors. The promising material so collected needs to be tested at many locations so thet varieties can be identified for various purposes. The collabortion of Forest Research Institute, Dehra Dun, State forest departments and agricultural universities will be most useful in this venture. Once the varieties/selections for specific purposes are identified and utilisation avenues worked out, ICAR and State Extension Agencies can play a role in spreading of such promising materials.

For multiplication and spread of bamboo resources, areas not used for agricultural crops, and marginal lands, can be taken up for bamboo cultivation. Bamboo can be developed as an agricultural crop under social forestry/agro-forestry for making this plant a potential crop in the rural areas. This will include study of quicker methods of multiplication, using tissue culture techniques. The research work done by Department of Botany, University of Delhi under the able leadership of Prof H.Y. Mohan Ram is noteworthy in this direction. However, a centre specifically for tissue culture, and sites for *in situ* conservation of bamboo genetic resources calls for careful consideration—possibly to be located in north-eastern and the western ghat regions.

The research programmes on bamboo should also include import of bamboo genetic resources especially from China, Indonesia and Japan. Monopodial bamboos from these countries can be procured initially for exploitation. The programmes should also take care of diseases and pests of bamboos, with are so important in this case. For example, the blight problem, existing in Bangladesh should not spread to the areas in India.

Other uses of bamboos, as vegetables,

in handicrafts, as construction material and for paper industry also need to be studied more and popularised. Edible bamboos giving an excellent tasty shoots/vegetable material, can be introduced from neighbouring countries. Similarly, thrust to handicraft industry, utilisation of bamboo for construction/irrigation purposes and strengthening paper and pulp industry include studies on silviculture to establish bamboo plantations for industries, timber engineering for giving a boost to bamboo as construction/irrigation purposes material and paper and pulp technology to help paper industry. All this will, in turn, greatly help rural economy.

Epilogue

Bamboos are indeed, a group of plants which are so vital for the rural populations owing to their multifarious uses in almost all needs of life. They are important sources of livelihood for the tribal populations and certainly need greater attention. They are not only important from the point of improving the economy of village people and increasing revenues through industry, but are equally important in amelioration of the deteriorating environment. It is a good soil conservation material, and hence their plantations in lands where soil erosion is severe, particularly in hill slopes, river banks etc. and also on marginal lands, as stated before, can check this problem. The call for monitoring of our bamboo resources and their planned exploitation, utilisation and above all, conservation (both *ex situ* and *in situ*) is decidedly then, most urgent in national context and deserves priority action. It is gratifying that serious effors at national level are being made by ICAR and IFERT/FRI, and in this region of south/south-east Asia and the Far East by the International Development Research Centre, Canada, through their Regional Office located in New Delhi.

SUMMARY

This paper examines the distribution and diversity of different bamboos taxa in Indian context. The overall bamboo genetic resources scenario in the country is discussed to take stock of existing national resources to meet the increasing demand for exploitation of economically useful bamboo species and their conservation.

बासों के जननशास्त्रीय ससाधन – भारतीय परिप्रेक्ष्य

एस० मौर्य व आर०के० अरोड़ा

सारांश

इस अभिपत्र में भारतीय सदर्भ में बांसों की विभिन्न जातियों–प्रजातियों का वितरण और विविधता परीक्षित किए गए हैं। देश में बांस के जननिक संसाधनों की समग्र परिदृश्य राष्ट्रीय साधनों की वर्तमान स्थिति समझाने के लिए विवेचित किया गया है ताकि बाँस की अर्थिकदृष्टि से उपयोगी जातियों का समुपयोजन बांस की बढ़ी हुई मांग पूरा करने के लिए किया जा सके और इन जातियों का संरक्षण भी किया जा सके।

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BAMBOO IMPROVEMENT WORKS IN ARUNACHAL PRADESH

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Introduction

Arunachal Pradesh has vast resources of bamboo having more than 30 species in wilderness The territory is inhabited by tribal people and bamboo is one of the most important item of their daily use in one form or the other such as, vegetable, pickle, cooking food in it, water container, water pipe, torches, bows and arrows, fencing, firewood, house post and splited bamboos used in walls of temporary (mud plastered) and semi-permanent (cement plastered) buildings which last long and withstand earthquakes. Most of the local people grow bamboos in their compound and fields. After meeting their own requirements, they sell them and get some additional income. Keeping in view the multipurpose uses of bamboo and socio-economic needs of local people, selection of plus bamboo (entire clump) was taken up during 1980 with the objective to establish germ-plasm banks of improved materials and to multiply it for supplying to the villagers. The work done in Arunachal Pradesh is perhaps first of its kind in India. Selection of plus bamboo was done on phenotypical characters and important species included were, *Bambusa balcooa, B. nutans, B, pallida, B. tulda, Dendrocalamus giganteus, D. hamiltonii* (local name Nangal and Nal).

Material and Methods

Selection of condidate plus bamboo of above mentioned 8 species were taken up from 1980 onwards. The main characters considered for the selection of clumps were, number of culms per clump, height of the culms, thickness of culm, girth of culms, length of internode and disease and pest free culms. Selection of *Dendrocalamus hamiltonii* clumps were made from the natural bamboo forests whereas clumps of remaining 7 species were selected from the bamboo grown in the villages.

The active selection of candidate plus bamboo was done upto 1983 though it continued later also and the area covered was eastern and western parts of Arunachal Pradesh and Assam. During this process a large number of clumps were screened, their record was maintained and among the condidate plus bamboo final plus bamboo were selected in the early part of 1984 and were properly numbered. Care was taken to select only one plus bamboo of a given species from one locality. The plus bamboo selected (details given in Table 1) from the candidates are listed below :

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Species	Candidate plus bamboo	Plus bamboo selected
Bambusa balcooa	58	15
B. nutans	14	8
B. pallida	18	12
B. tulda	82	28
*Nangal (*Bambusa* sp.)	7	5
*Nal (*Bambusa* sp.)	2	2
Dendrocalamus hamiltonii	14	4
D. giganteus	4	3

*Local name

Pits of 60 cm^3 at a spacing of 8 × 8 m were dug up in the month of March and were later filled with cowdung and top soil. Offsets of the plus bamboos were purchased from the villagers at the rate of Rs. 5 to 10/- per rhizome, depending upon the species, and germ-plasm banks were raised during May, 1984 at Van Vigyan Kendra, Chessa over 1.0 hecrare and at Namsai (Lathaw) over 5.0 hectares (Details given in Table 2).

In addition, preservation plots of *Bambusa pallida, Dendrocalamus hamiltonii* and *Pseudostachyum polymorphum* were selected for *in situ* gene conservation at Namsai (Lathaw) and Jairampur.

Observations

It can be seen from Table 2 that mortality is more at Namsai (Lathaw) compared to Chessa. The reasons were bad communication and time gap between offset uprooting and planting. Regarding performance of plus bamboo BB/CH-4 (*B. balcooa*) has done better in height, girth and culm production. Among *B. tulda* BT/NS-13 has shown lead in girth and culm production whereas BT/CH-7 has done better in height. In case of *B. pallida* BP/CH-3 has done better in height and culm production and BP/CH-7 in girth. BN/CH-1 has done better among five plus bamboo of *B. nutans* in girth, height and culm production. In case of *D giganteus* performance cannot be judged for a single plus bamboo and growth of culms is also poor, probably due to flowering. Among Nangal, CH-4 has shown lead in height and culm production over others and CH-2 has gained higher girth.

Flowering was observed in three clumps of BB/CH-6 in January, 1986, and one clump died and the two again flowered in January, 1987. The counter check was done with the parent clump which also flowered but no mortality and seed set was observed. In case of DG/CH-3 two clumps flowered in January, 1986. Parent clump was checked which also flowered but no seed set was observed. Five clumps of BN/CH-2 also flowered in 1987 and two clumps died.

Further, it can be said that a germplasm base for some important bamboo has been established which will be used through vegetative propagation for further multiplication and supply of improved rooted cuttings to the villagers. It is only a beginning and there is plenty of scope for its further improvement through addition of more plus bamboo and inter-specific breeding for obtaining better characters.

Table 1

Plus bamboo data

Plus bamboo clump No.	No. of dry culms per clump	No. of culms cut per clump	No. of matured culms per clump	No. of new culms per clump	Thickness of culms (mm)	Average girth of culms (cm)	Length of internodes (cm)	Average height of culms (m)
1	2	3	4	5	6	7	8	9
1. *Bambusa balcooa*								
BB/CH-1	4	200	270	50	45	42	24	23
BB/CH-2	2	100	250	40	45	43	24	22.5
BB/CH-3	2	100	150	28	40	39	26	22
BB/CH-4	14	150	167	23	30	36.6	25	22
BB/CH-5	2	40	100	50	40	41.5	24	22.5
BB/CH-6	3	230	70	40	45	41	26	23
BB/CH-7	9	150	180	57	30	38	27	24
BB/CH-8	1	120	285	66	40	37	22	20
BB/CH-9	5	200	245	75	49	38	26	21.5
BB/NS-1	14	53	121	16	40	33.2	25	21.3
BB/NS-2	17	35	125	14	45	32	24	20.6
BB/NS-3	—	31	209	32	43	31	25	21
2. *Bambusa tulda*								
BT/CH-1	2	70	280	60	20	28	38	18.5
BT/CH-2	—	60	200	25	20	29	40	19.5
BT/CH-3	20	200	400	50	20	27	42	23
BT/CH-4	1	40	200	50	20	30	42	18
BT/CH-5	6	10	198	59	15	26 3	42	20
BT/CH-6	23	65	251	43	15	25.5	45	20.5
BT/CH-7	7	270	130	25	15	26	44	20 6
BT/CH-8	5	130	190	85	20	27	40	17.5
BT/NS-1	5	46	400	41	20	23.2	40	19.1

(*Contd*...)

1	2	3	4	5	6	7	8	9
BT/NS-2	9	48	434	39	23	20.2	44	18.6
BT/NS-3	8	41	241	27	22	22 8	42	19.4
BT/NS-4	5	28	162	44	20	25.7	40	18.2
BT/NS-5	27	62	284	58	20	26.6	44	20
BT/NS-6	7	31	289	20	21	26.4	43	21
BT/NS-7	10	113	278	43	25	25.9	49.5	23
BT/NS-8	7	117	288	46	20	24.5	43	24
BT/NS-9	1	45	224	24	25	24.7	48	22
BT/NS-10	—	5	240	21	25	24.8	48.5	22
BT/NS-11	4	203	305	32	24	23.4	42	18.7
BT/NS-12	—	37	287	19	19	18.6	46	19
BT/NS-13	3	79	178	17	21	23.9	41	18.1
BT/NS-14	—	9	312	38	20	22	38	21.3
BT/NS-15	2	7	236	40	21	23.3	40	23.2
BT/NS-16	3	18	235	32	23	26	41	24.4
BT/NS-17	4	43	277	27	21	23	44	23.18
BT/NS-18	13	66	190	16	25	25	43	21
BT/NS-19	3	222	207	19	23	23	44	18
BT/NS-20	23	21	267	11	20	24	48	19
3. *Bambusa pallida*								
BP/CH-1	3	100	150	20	20	27	38	17.5
BP/CH-2	2	40	85	35	20	28	40	17.5
BP/CH-3	20	108	290	45	15	24.3	43	17.5
BP/CH-4	4	15	300	60	20	28	37	18
BP/CH-5	2	200	300	120	20	29	37	20
BP/NS-1	—	68	302	49	15	22.5	53	18
4. *Bambusa nutans*								
BN/CH-1	16	120	300	60	20	37	36	19
BN/CH-2	1	8	80	30	20	55	35	18.5

(*Contd...*)

1	2	3	4	5	6	7	8	9
BN/CH-3	10	60	300	78	30	31	32	20
BN/CH-4	3	25	180	24	20	22.6	37	18.8
BN/CH-5	6	35	225	50	20	26	34	18
BN/CH-6	17	280	60	14	25	31	28	20
5. *Dendrocalamus giganteus*								
DG/CH-1	—	50	100	8	20	49	28	20
DG/CH-2	2	40	105	30	20	55	30	20.5
DG/CH-3	1	90	75	11	20	54	32	23
6. *Dendrocalamus hamiltonii*								
DH/CH-1	8	170	190	28	29	45	27	23
DH/CH-2	12	110	250	24	30	47	25	25
DH/CH-3	4	80	200	40	32	43	26	24.5
DH/CH-4	3	50	160	30	30	46	26	24
7. Nangal								
CH-1	4	18	70	16	25	27.5	34	16.5
CH-2		100	150	30	25	33	31	21
CH-3	—	120	150	32	20	29	34	16
CH-4	—	35	40	15	20	20	30	16.5
CH-5	3	100	115	40	20	31	32	17.5
8. Nal								
CH-1	10	20	320	100	10	9.5	32	10
CH-2	8	30	400	120	10	12.5	42	11.5

Table

Germ-plasm

Name of place	Plus clump No.	No. of offsets planted	Date of planting	Survival		December, 1985 Average		
				Sep. 1984	Dec. 1985	No. of new culms	Ht. (m)	Girth (cm)
1	2	3	4	5	6	7	8	9
1. *Bambusa balcooa*								
Chessa	BB/CH-1	5	10.5.84	5	5	4	7.5	22
	BB/CH-2	5	„	5	5	3	6	19
	BB/CH-3	2	1.6.84	2	1	4	4	13
	BB/CH-4	5	3.5.84	5	5	6	8	24
	BB/CH-5	5	10.5.84	5	5	5	7	21
	BB/CH-6	6	14.5.84	6	6	5	7	17
	BB/CH-7	3	10.6.86	—	—	—	—	—
	BB/CH-8	3	„	—	—	—	—	—
	BB/CH-9	3	„	—	—	—	—	—
	BB/CH-10	3	„	—	—	—	—	—
	BB/CH-11	3	10.6.86	—	—	—	—	—
	BB/CH-12	3	10.6.86	—	—	—	—	—
Namsai	BB/NS-1	5	18.5.84	4	3	4	6.5	19
	BB/NS-2	5	„	1	1	3	6	6
	BB/NS-3	2	„	1	1	5	7.7	21.5
2. *Bambusa tulda*								
Chessa	BT/CH-1	4	16.5.84	4	4	4	6	12
	BT/CH-2	5	14.5.84	4	3	3	5.8	15
	BT/CH-3	5	„	5	4	5	6.5	14
	BT/CH-4	5	„	5	5	3	6	16
	BT/CH-5	2	5.5.84	1	1	6	6.5	12
	BT/CH-6	2	„	1	1	5	6	10.5
	BT/CH-7	3	„	1	1	7	8	20
	BT/CH-8	2	1.6.84	1	1	9	5	11
Namsai	BT/NS-1	10	17.5.84	5	4	4	5.3	10.5
	BT/NS-2	5	„	4	4	5	6	12

2

bank data

December, 1986 Average			Survival in Dec. 1986	December, 1987 Average			Total culms upto December, 1987
No. of New culms	Ht. (cm)	Girth (cm)		No. of New culms	Ht. (m)	Girth (cm)	
10	11	12	13	14	15	16	17
4	8	23	5	5	8.5	25	13
3	6.5	21	5	5	7	23	11
4	5	16	1	4	6.2	19	12
6	8.5	24	5	8	9.5	26	20
5	8	24	5	7	9	25	17
5	7.2	19	5	6	8	22	16
2	—	—	2	4	5	15	6
2	—	—	3	4	4.5	14	6
2	—	—	3	4	4.3	15	6
3	—	—	3	5	3.5	10	8
2	—	—	2	4	5	15	6
2	—	—	3	5	4.5	13	7
4	7	20	3	5	8.2	21	13
3	6.8	10	1	6	8	20	12
5	8	22	1	7	9	24	17
4	6	12	4	5	6.5	12	13
3	6	15	1	3	6.5	15	9
5	7	17	5	5	8	20	15
3	6.5	16	5	6	8	17	12
6	6.5	12	1	7	7.2	14	19
5	6	10	1	5	6.5	11	15
7	8	16	1	7	9	20	21
9	5	11	1	10	5.5	12	28
4	6	12	4	5	6.8	15	13
5	7	14	4	7	8	16	17

(*Contd...*)

1	2	3	4	5	6	7	8	9
	BT/NS-3	5	17.5.84	1	—	—	—	—
	BT/NS-4	5	19.5.84	4	2	4	5	16
	BT/NS-5	5	,,	4	3	3	4	10
	BT/NS-6	5	17.5.84	2	1	6	4.5	13
	BT/NS-7	5	19.5.84	5	4	6	6	18
	BT/NS-8	5	17.5.84	3	3	5	6	13
	BT/NS-9	5	,,	4	4	3	5	14
	BT/NS-10	5	19.5.84	2	2	—	—	—
	BT/NS-11	5	,,	3	2	2	4	9
	BT/NS-12	5	,,	3	3	7	5.5	15
	BT/NS-13	5	,,	2	1	10	7.5	19
3. *Bambusa pallida*								
Chessa	BP/CH-1	5	14.5.84	5	3	3	3.3	5.5
	BP/CH-2	4	16.5 84	4	2	6	3.5	6
	BP/CH-3	5	30.4.84	5	3	18	7.5	15
	BP/CH-4	5	10.5.84	5	5	8	6	12
	BP/CH-5	2	5.5.84	2	1	6	6	14
	BP/CH-6	2	5.5.84	2	1	3	5	14
	BP/CH-7	1	,,	1	1	5	5.5	18.5
	BP/CH-8	1	1.6.84	1	1	4	6	16
	BP/CH-9	3	1.6.86	—	—	—	—	—
	BP/CH-10	3	”	—	—	—	—	—
	BP/CH-11	3	,,	—	—	—	—	—
Namsai	BP/NS-1	5	18.5.84	1	1	5	3.8	8.5
4. *Bambusa nutans*								
Chessa	BN/CH-1	5	7.5.84	5	4	8	10	21.5
	BN/CH-2	5	19.5.84	5	5	7	8.5	20
	BN/CH-3	4	1.6.84	4	1	2	5.5	10
	BN/CH-4	5	30.4.84	5	4	6	7	14
	BN/CH-5	5	5.5.84	5	5	7	6.5	17
	BN/CH-6	2	6.6.88	—	—	—	—	—
	BN/CH-7	3	”	—	—	—	—	—
	BN/CH-8	4	”	—	—	—	—	—

10	11	12	13	14	15	16	17
—	—	—	—	—	—	—	—
4	6	16	2	6	7.5	18	14
3	5	12	3	5	7	15	11
6	5.2	14	1	7	6.5	17	19
6	6.5	18	4	8	8	20	20
5	6.2	13	3	5	7.5	15	15
3	6	15	4	4	8	18	10
—	—	—	—	—	—	—	—
2	4.5	11	2	4	5.2	13	8
7	6	16	3	9	7.2	18	22
10	7.8	20	1	12	8.5	21	32
3	5	16	3	4	7.75	20	10
6	5	12	2	8	7.5	17	20
18	7.5	16	3	18	8.5	20	54
8	7	13	5	10	8.2	16	26
6	6	16	1	7	8	20	19
4	5.8	15	1	5	7.2	17	12
5	6.5	21	1	5	9	26	15
5	6.5	18	1	5	8.5	20	14
2	—	—	3	3	5.2	12	5
2	—	—	2	2	6	14	4
2	—	—	2	2	4.2	14	4
5	4.5	10	1	5	5	12	15
8	10.5	21.5	4	10	11	22	26
7	8.5	20	5	8	9	20	21
2	6.3	12	4	3	7	14	7
6	8	17	5	6	9.5	20	18
7	8	18	4	8	9.5	22	21
2	—	—	2	2	8	18	4
2	—	—	3	3	4.5	15	5
2	—	—	3	3	5	15	5

(*Contd...*)

1	2	3	4	5	6	7	8	9
5. *Dendrocalamus giganteus*								
Chessa	DG/CH-1	4	16.5.84	4	—	—	—	—
	DG/CH-2	4	28.5.84	4	3	4	5.5	13
	DG/CH-3	4	28.5.84	4	2	—	—	—
6. Nangal (*Bambusa* sp.)								
Chessa	CH-1	5	14 5.84	5	2	5	5	12
	CH-2	2	16.5.84	2	1	1	4.5	15
	CH-3	2	5.5.84	2	1	1	2.5	5
	CH-4	5	14.5.84	5	4	5	7	15
	CH-5	5	1.6 84	5	5	4	5.5	15
7. Nal (*Bambusa* sp.)								
Chessa	CH/1	1	27.4.84	1	—	—	—	—
	CH/2	1	27.4.84	1	1	7	4	7

N.B.—BB/CH-6 : 3 clumps out of 6 flowered during 1986—87, no seed setting was observed, one clump died after flowering.

BN/CH-2 : 5 clumps out of 5 flowered during 1987, no seed setting was observed, two clumps died after flowering.

DG/CH-3 : 2 clumps out of 2 flowered during 1985, no seed setting was observed, two clump died after flowering.

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SUMMARY

Arunachal Pradesh is very rich in bamboo having more than 30 species in wilderness. Bamboo is used by the tribal people for a variety of purposes and is very much linked with their socio-economic needs. Keeping in view the importance of bamboo, its improvement work was taken up in Arunachal Pradesh during 1980 with the objective to establish germ-plasm banks of improved materials and to multiply it for supplying to the villagers. Eight important species of bamboos were taken up and plus bamboo were selected from the bamboo grown in the villages and also from natural forests. Offsets were purchased from the villagers and bamboo germ-plasm banks were established during 1984 over 6 hectares at Chessa and Namsai. Among the plus bamboo BB/CH-4, BT/NS-13, BT/CH-7, BP/CH-3, BP/CH-7, BN/CH-1, Nangal CH-2 and CH-4 have shown superiority over other plus bamboo.

10	11	12	13	14	15	16	17
—	—	—	—	—	—	—	—
4	4.5	16	3	4	5.5	18	12
—	—	—	—	—	—	—	—
5	6	16	5	5	8.5	20	15
1	5	17	1	2	6.5	20	4
2	4	16	2	2	6	20	5
5	7	15	5	6	7.5	18	16
5	6	16	5	6	8	20	15
—	—	—	—	—	—	—	—
7	4	8	1	10	5	9	24

अरुणाचल प्रदेश में बाँसों के परिष्कार कार्य

बी०एस० बेनीवाल व एन०बी० सिंह

सारांश

बाँस की दृष्टि से अरुणाचल प्रदेश का स्थान बहुत ऊंचा है, क्योंकि यहाँ बाँसों की तीस से भी अधिक जातियाँ जंगली अवस्था म पाई जाती हैं। यहां के आदिवासी बांस को अनेक प्रयोजनों में, काम में लगाते हैं और यह उनकी सामाजार्थिक आवश्यकताओं से बहुत अधिक जुड़ा हुआ है। बांसों का महत्व ध्यान में रखकर, बाँसों के परिष्कार का कार्य अरुणाचल प्रदेश में 1980 में आरम्भ किया गया जिसका उद्देश्य परिष्कृत वस्तु के पित्रद्रव्य (जर्मप्लाज्म) का सग्रह बनाना और तदुपरान्त गांव वालों को देने के लिये इनको बढाना था। इसमे बांस की आठ महत्वपूर्ण जातियां ली गई और उनके श्रेष्टतर बांस गाँवों तथा प्राकृ तक वन मे लगे हुये बाँसों मे से चुने गये। बासों के टुकड़े गांव वालों से खरीदे गये और 1984 में चीम्सा और नामसाई में लगभग 6 हेक्टेयर भूमि में बांस का पित्रद्रव्य संग्रह बनाया गया। श्रेष्टतर बांसों में अन्य श्रेष्टतर बांसों की तुलना मे बीबी/सीएच–4, बीटी/एनएस–13, बीटी/सीएच–7, बीपी/सीएच–3, बीपी/सीएच–7, बीएन/सीएच–1, नंगल सीएच–2 और सीएच–4 अधिक अच्छे रहे हैं।

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HYDRATION-DEHYDRATION TREATMENTS FOR IMPROVED SEED STORABILITY OF BAMBOO (*DENDROCALAMUS STRICTUS* L.)

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Introduction

Propagation of bamboo by seed, though easier than other methods such as cutting and air-layering, may not always be feasible because of long flowering cycles and poor viability of bamboo seed (Bahadur, 1979; Varmah and Bahadur, 1980). Generally bamboo seed loses viability in about 2-3 months after harvest. In view of the great importance of bamboo preservation of seed viability by a simple method is essential for more efficient propagation of bamboo from seed.

In this laboratory, easily practicable hydration-dehydration treatments have been developed to maintain the vigour and viability of many agricultural, horticultural and forest-tree seeds (Basu, 1976; Basu and Rudrapal, 1982; Basu and Mandal, 1986; Sur *et al.*, 1987). Such treatments very effectively maintained the vigour and viability of short lived seed of bamboo (Sur *et al.*, 1988).

In the present study, besides the hydration-dehydration treatments, the efficacy of certain compounds, which influence germinability, have also been studied to evaluate their role in the maintenance of seed vigour and viability of bamboo.

Materials and Methods

Bamboo (*Dendrocalamus strictus* L.) seeds were collected from the Forest Department of West Bengal in February, 1988. Seeds were thoroughly cleaned and dried in a drying cabinet at 35 ± 1°C for 3 days and kept in a sealed glass bottle under ambient conditions in the laboratory. A portion of the seeds was also stored in a refrigerator at — 10°C to prevent deterioration and served as non-aged control. The method of hydration-dehydration (SD, soaking-drying and MED, moisture equilibration-drying) was the same as described earlier (Sur *et al.*, 1988).

For soaking-drying (SD) treatments, one month old seeds were soaked in two volumes of water (200 ml/100 g of seed) or in a solution of sodium phosphate (dibasic, 10^{-1}M), gibberellic acid (10^{-5} M), kinetin (10^{-6} M) and ethephon (10^{-3} M) for 6 hr. The seed was then surface-dried by keeping under the electric fan for one hour followed by drying back to the original weight in a drying cabinet at 35 ± 1°C.

Moisture equilibration-drying treatment was done by exposing the seeds to a water-saturated atmosphere for 48 hr avoidingd irect contact with water. After

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48 hr of moisture equilibration, seeds were dried back to their original weight along with the untreated seeds (control). After drying, the moisture content of the treated (SD and MED) and untreated (control) seeds was 9% and seeds were subjected to accelerated ageing at 92% RH and 40°C for 5 days. Germination test was done in sand before and after accelerated ageing. Data on germination percentage and growth of shoot were recorded after 15 days. Three replications were provided for each set of experiment.

Results and Discussion

Immediately after the hydration-dehydration treatment (before ageing), germination percentage and seedling growth were similar in the treated and untreated seeds. After accelerated ageing, soaking-drying (SD) and moisture equilibration-drying (MED) treatments effectively prevented the loss of vigour and viability of seeds; SD proved better than MED in the maintenance of seed vigour and viability (Table 1). The results of the present investigation confirm our earlier findings that the SD and MED treatments could maintain the germinability of stored seed whereas the untreated (control) seeds completely failed to germinate after 4 months of storage (Sur *et al.*, 1988).

As regards the effects of chemicals, except with ethephon treatment, there was no significant effect of the treatments, with or without chemicals, on germination percentage and seedling growth before ageing (immediately after treatment). Soaking with ethephon followed by drying adversely affected germinability as well as seedling growth (Table 2).

Table 1

Effect of hydration-dehydration treatments on the germinability of bamboo seed subjected to accelerated ageing (92% RH and 40°C) for 5 days.

Treatments	Germination		Mean seedling length (mm)
	(%)	Arc-sin value	
Non-aged control	62	52.0	254
Aged control	22	28 0	120
Soaking-drying (SD)	51	45.7	239
Moisture equilibration-drying (MED)	43	40.7	210
L.S.D. at 0.05 P	—	3.6	9.8
,, 0.01 P	—	5.4	14.9

Non-aged control—seeds were stored at 10°C; aged control—untreated seeds were aged (92% RH and 40°C for 5 days) along with the treated seed.

SD-soaking was done for 6 hr followed by drying; MED-moisture equilibration with a water-saturated atmosphere was done for 48 hr followed by usual drying back.

Soaking-drying treatments employing sodium phosphate extended the longevity of seeds subjected to accelerated ageing at 92% RH and 40°C for 5 days (Table 3). Water treatment (SD) alone greatly minimized the deterioration of seeds but seeds treated with disodium hydrogen phosphate maintained a higher level of germinability. Although GA showed almost similar germination percentage as water, an improvement of seedling vigour was observed after storage. Kinetin and ethephon did not minimize the loss of germinability; on the contrary, both the chemicals showed a post-storage reduction in germinability (Table 3).

Table 2

Effect of different Physico-chemical treatments on the germinability of bamboo seed immediately after treatment (before accelerated ageing)

Treatments	Germination		Mean seedling length (mm)
	(%)	Arc-sin value	
Non-aged control	55	48.0	251
Aged control	53	46.7	247
Soaking-drying (SD)			
Water	54	47.7	251
Sodium phosphat (dibasic. 10^{-4}M)	55	48.0	256
Gibberellic acid 10^{-5}M)	54	47 3	260
Kinetin (10^{-6}M)	47	43.0	236
Ethephon (10^{-3}M)	30	33.3	210
L.S D. at 0.05 P	—	4.5	9.5
,, ,, 0.01 P	—	5 2	13.3

The present investigation clearly shows that the response of the treatments in bamboo seeds under accelerated ageing is broadly similar to those obtained by Sur *et al.* (1988) under natural ageing. As such, the easily practicable hydration-dehydration treatments alone, or with effective chemicals such as disodium hydrogen phosphate. may be used for maintaining the vigour and viability of stored bamboo seed.

Table 3

Effect of different Physico-chemical treatments on the germinability of bamboo seeds after accelerated ageing at 92% RH and 40°C for 5 days

Treatments	Germination		Mean seedling length (mm)
	(%)	Arc-sin value	
Non-aged control	58	50.3	264
Aged control	21	27.3	118
Soaking-drying (SD)			
Water	40	39.3	227
Sodium phosphate (dibasic, 10^{-4}M)	51	45.7	252
Gibberellic acid (10^{-5}M)	43	41.0	258
Kinetin (10^{-6}M)	20	26.3	206
Ethephon (10^{-3}M)	19	26.0	158
L.S.D. at 0.05 P	—	4.0	35.2
,, ,, 0.01 P	—	5.6	49.3

Acknowledgements

The authors are thankful to University Grants Commission, New Delhi for financial assistance.

SUMMARY

Soaking of bamboo seeds (*Dendrocalamus strictus* L.) in water or a dilute solution of disodium hydrogen phosphate (10^{-4}M) for 6 hr, followed in either case by drying back, greatly reduced their deterioration under accelerated ageing at 92% RH and 40°C for 5 days. Hydration by moisture equilibration with a water saturated atmosphere for 48 hr followed by drying also slowed down the loss of vigour and viability of seeds. Soaking-drying treatment

was, however, more effective than the moisture equilibration-drying treatment. Although the soaking-drying treatment with low concentration of disodium hydrogen phosphate (10^{-4}M) proved better than water (SD) for maintaining vigour and viability, GA treatment showed better seedling growth (not germination percentage) than the other treatments. Kinetin and ethephon adversely affected post-storage germinability.

बांस (डैंड्रोकैलेमस स्ट्रिक्टस०) के बीज की भण्डारणीयता में परिष्कार के लिए जलीयन-निर्जलीयन उपचार करना

कल्पना सूर, ए०के० लाहिड़ी व आर०एन० बसु

सारांश

बांस (डैंड्रोकैलेमस स्ट्रिक्टस लिन०) के बीजों को पानी अथवा डायसोडियम हाड्रोजन फास्फेट के मन्द विलयन, 10^{-4} एम, में 6 घटे तक डुबाने और फिर उन्हें सुखाने से 92% आपे० नमी और 40 से० तापमान जैसी त्वरित जरापण दशाओं में 5 दिन तक रखने पर भी उनका विघटन बहुत घटा दिया। जल सतृप्त वातावरण के तुल्य नमी द्वारा 48 घटे तक जलीयन और उसके बाद सुखाने से बीजों की ऊर्जा और जीविष्णुता घटने में मन्दता आई। नमी तुल्यता लाना सुखाना उपचार की तुलना में भिगोना-सुखाना उपचार अधिक प्रभावकारी रहा। यद्यपि सादे पानी में भिगोने-और सुखाने की तुलना में डायसोडियम हाइड्रोजन फास्फेट का मन्द सकेन्द्रण (10^{-4} एम) लेकर उपचार करना ऊर्जस्विता और अकुरण क्षमता बनाए रखने के लिए अच्छा रहा, जिबेरेलिक अम्ल उपचार पौधों की बढ़वार के लिए (अकुरण प्रतिशत के लिए नहीं) अन्य उपचारों से बढ़कर रहा। भण्डारण के पश्चात् बीजों की अंकुरण क्षमता बनी रहने पर काइनेटिन और एथेपोन का कुप्रभाव पड़ा।

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VEGETATIVE PROPAGATION OF *DENDROCALAMUS STRICTUS* THROUGH MACRO-PROLIFERATION

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Introduction

Bamboos are normally propagated by seed, by offsets by division or by stem or rhizome cuttings. The commonest method is by planting offsets just before the rainy season (Bhatnagar, 1974). However, the availability of bamboo offsets is very limited and are also very expensive being difficult to extract and transport.

Moreover, seeds of *D. strictus* are available in bulk quantity only after long intervals, say 30-45 years, when gregarious flowering occurs. Seeds are short lived hence cannot be stored for sowings in future years. Very limited supply of seeds are, however, available due to sporadic flowering and these may be used for raising seedlings.

Since bamboo seedlings possess inherent proliferating capacity and offset planting capability to reproduce itself, the young sesdlings can be utilized for multiplication vegetatively by exploiting such characters in bamboo seedlings. Banik (1985) stressed the need of detailed scientific study on such a macro-proliferation of bamboo seedlings to develop a new dependable technique for bamboo propagation at least for a few years. In view of the restricted availability of seed of *D. strictus* and the limited success achieved in vegetative propagation through culm cuttings, a study on the propagation of this species had been undertaken through seedling multiplication to maintain a continuous supply of large number of seedlings for a couple of years.

Material and method

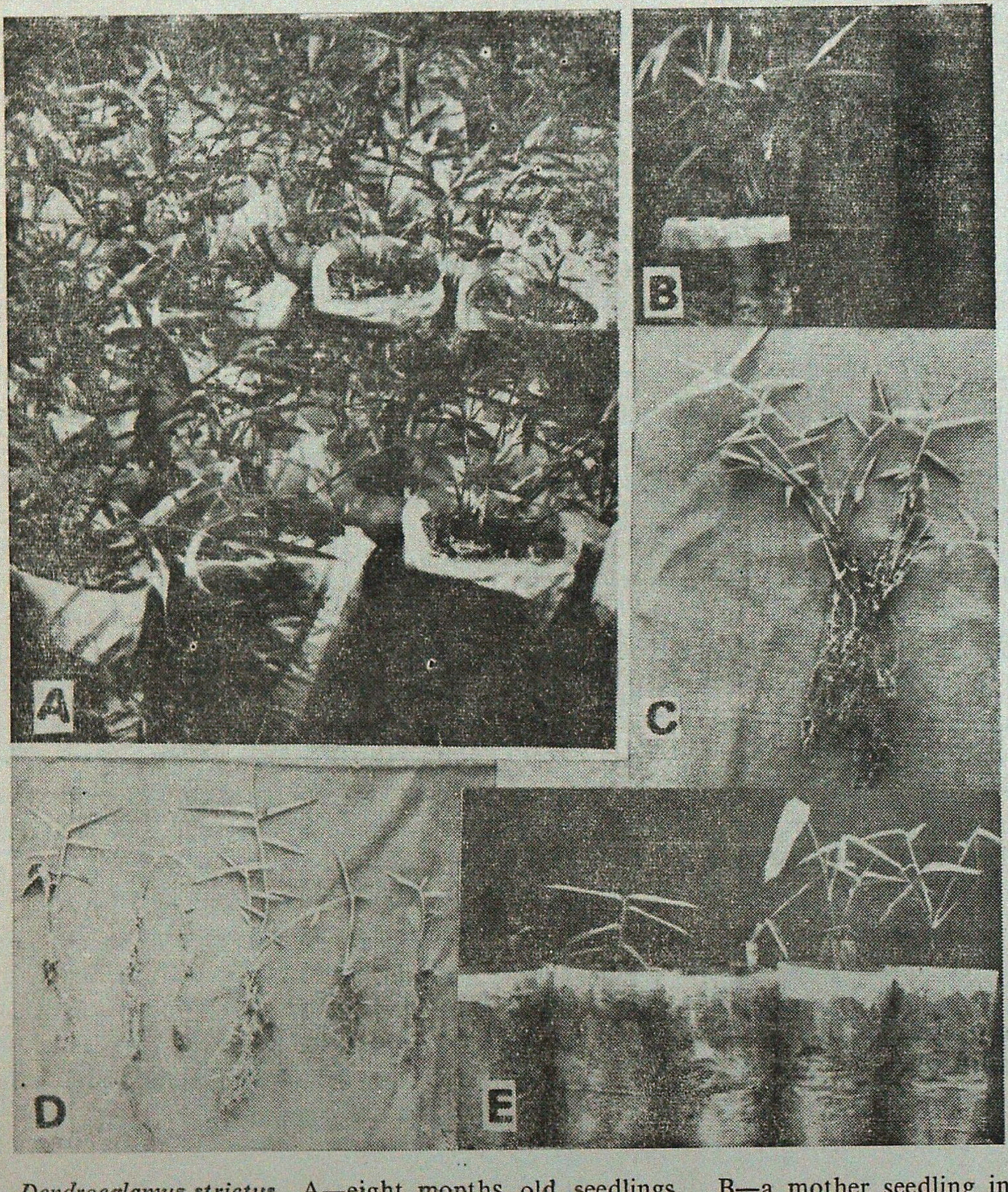
Young seedlings of *D. strictus* were picked up from the forest floor and transplanted in polybags of 24 × 18 cm size in the first week of August. Each polybag was earlier filled with mixture of sieved soil, sand and farm yard manure in 1 : 1 : 1 ratio weighing 2 kg in each polybag. These polybags were divided into two sets of 50 polybags under each set. The first set of polybags were devoid of NPK treatment whereas, the second set was applied with NPK The first dose consisted of Urea (N=46.4%)=0.05 gm @ 25 kg N/ha dose; Super Phos. (P_2O_5=16%)=0 59 gm @ 100 kg P_2O_5/ha dose; and Muriate of potash (K_2O=56-60%)=0.04 gm @ 25 kg K_2O/ha dose mixed in 30 ml of water, added to each polybag of the second set, prior to planting of young seedlings of *D. stricuts* picked up from the forest floor. One young seedling was planted in each of the polybag of both the sets and kept in shade for three days. All the seedlings planted in polybags established well and then the same were shifted in the open under direct sunlight.

The second dose of fertilizer viz., Urea (N=46.4%)=0.12 gm @ 25 kg N/ha dose and Muriate of potash (K_2O=56-60%) =0.12 gm @ 75 kg K_2O/ha dose was applied only to the seedlings of second set at the interval of one month from the day of planting of seedlings in polybags. The seedling of both the sets were maintained by regular watering and weeding upto 8 months i.e., upto April when the young culms ranging 3-8 in number were produced in each of the polybag of both the sets. Melathion 0.2% was lightly sprayed at an interval of 2 months as prophylatic treatment for protection against insect attack. In the first week of April, the seedlings of both the sets having culms, rhizome and roots were carefully removed from the polybags. Each proliferating culm along with some rhizome and roots was separated and again planted in fresh polybags of 24 × 18 cm size containing soil mix 2 kg in each polybag for further growth and development (Fig. 1). Out of these freshly planted propagules, 1/6 propagules were retained for furture multiplication purposes in the nursery where as, 5/6 propagules were available for field planting during monsoon season.

Results and Discussion

The data recorded on the production of culms, rhizome and roots by the seedlings of *D. strictus* is presented in Table 1. On the whole, seedlings in Set No. 2 were found to perform better than those in Set No. 1 in every respect. On an average four times propagules were obtained from seedling in Set No. 1 while nearly 6.2 times propagules, were obtained in case of seedlings treated with NPK. In case of *Bambusa tulda* three proliferated seedlings have been obtained in 9 months time (Banik, 1985). Further, Banik (1985) suggested that such process of seedling multiplication should not be continued for long time (e.g. not more than 10 years in *Bambusa tulda*) as the time gap between the last multiplication and flowering gets shorter. Multiplied seedling become physiologically older as the time passes from the date of mother seedling germinated. With the result, the last multiplied seedlings are likely to start flowering due to their physiological maturity before attaining the merchantable culm size. Thus, the vegetative propagation of bamboo through seedlings proliferation has been found to be one of most dependable techniques. This can yield about four to six times propagules of the original seedling stock in eight months time. Out of this, 1/6th propagules can be retained in nursery for future multiplication purposes and 5/6 propagules are available for planting purposes. It is beneficial to apply NPK to the young seedlings for improving the production of propagules at nursery stage. The proliferated seedlings, thus produced, remain small in size due to continuous rhizome separation. This is additional advantage as such seedlings are easy to handle and transport.

Fig. 1



Dendrocalamus strictus A—eight months old seedlings, B—a mother seedling in polybag, C—mother seedling uprooted from polybag showing well developed root system, profusely developed rhizome and culms, D—mother seedling separated into propagules having young culm, rhizome and roots, E—the young proliferated propagules planted in polybags.

Table 1

Dendrocalamus strictus propagule (culm, rhizome and roots) available from eight months old seedlings.

	Set No. 1 Soil Mix (Soil+Sand+ FYM 1 : 1 : 1)	Set No. 2 Soil Mix + NPK (Soil +Sand+ FYM 1 : 1 : 1)
No. of seedlings planted	50	50
Total No. of culms after 8 months	200	310
Culms		
Average number of culms per seedling	4.0	6.2
Average length of each culm (cm)	16.1	18.7
Average diameter of each culm (mm)	1.74	3.2
Average number of nodes in each culm	5.1	6.6
Average fresh weight of culms (gm)	5.3	7.5
Average dry weight of culms (gm)	4.0	4.8
Rhizome		
Average volume of rhizome (c.c.)	4.3	5.2
Average fresh weight of rhizome (gm)	7.0	8.3
Average dry weight of rhizome.	4.1	4.7
Roots		
Average number of roots per seedling	14.3	21.0
Average length of each root (cm)	19.2	20.5
Average fresh weigth of roots (gm)	4.3	6.7
Average dry weight of roots (gm)	2.0	3.5

SUMMARY

The propagation of *Dendrocalamaus strictus* **through seedling proliferation has been studied. It has been found that the mother stock of seedlings can be multiplied four to six times depending on fertiliser application in a period of eight months. The proliferated seedlings are easy to handle and transport as they remain small in size due to continuous rhizome separation. A methodology for multiplication of seedlings has been developed for** *D. strictus* **and is reported here.**

दीर्घ प्रगुणन विधि से डैंड्रोकैलेमस स्ट्रिक्टस बांसों का वर्धी प्रवर्धन

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सारांश

इस अभिपत्र में पौधों के प्रगुणन द्वारा डैंड्रोकैलेमम स्ट्रिक्टस के प्रवर्धन का अध्ययन किया गया है। ज्ञात यह हुआ है कि मूल वस्तु (मदर स्टॉक) को चार से छह गुने तक बढ़ाया जा सकता है जो आठ महीनों के दौरान

उर्वरक देने पर निर्भर है। प्रगुणित पौधे उठाने-रखने और लानेले-जाने में आसान है क्योंकि बार-बार शिफास्तम्भ से अलग करने से उनका आकार छोटा रहता है। पौधों के प्रगुणन का रीतिविज्ञान डैं० स्ट्रिक्टस को लेकर विकसित किया गया है तथा उसकी जानकारी इस अभिपत्र में दी गई है।

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VEGETATIVE PROPAGATION OF *BAMBUSA TULDA* USING GROWTH PROMOTING SUBSTANCES

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Introduction

The propagation of bamboos by seed is most successful but many of the bamboos flower and seed only two or three times in a century. Due to long inter-seeding intervals, the propagatian is done vegetatively Bamboo propagation by off-set and rhizome planting are most common methods applied in this country. However, the availability of these propagules is very limited and is useful only for small scale plantings. Besides, these propagules are very expensive being bulky, difficult to extract and transport. Culm segments are also used for propagation of bamboos (e.g., see Cabanday, 1957; Surendran *et al.*, 1983; Seethalakshmi *et al.*, 1983 and Sharma and Kaushal, 1985).

The role of growth regulators have been found to be positive for induction of better rooting and longer roots. Uchimura (1977) found that IBA treatment responded better than that of IAA and NAA for rooting of *Bambusa vulgaris.* Suzuki and Ordinaro (1977) reported that IBA treated two noded obliquely planted culm segments of one year old culms of *B. blumeana* gave 45% success whereas 80% and 60% success was achieved in case of *B. vulgaris* and *Dendrocalamus merritianus*, respectively. Seethalakshmi *et al*. (1983) found that Coumarin, NAA and a mixture of Coumarin and IAA gave the highest percentage of rooting in case of *Bambusa balcooa.* Surendran *et al* (1983) found that treatments with Coumarin, NAA and Boric acid showed better sprouting and rooting response than control treatment in case of *Bambusa arundinacea.*

In the present study efforts have been made to examine the effect of growth promoting substances in summer season (May) and rainy season (August) plantings on sprouting, rooting and rhizome formation of culm cuttings of *Bambusa tulda*—a native of eastern India, Bangladesh and Burma. It flowers at the age of 35-60 years (Suri and Chauhan, 1984). Due to sufficiently strong culms *B tulda* is used as building material, scaffolding and roofing.

Material and Methods

About one year old culms of *B. tulda* were extracted from the plantations at Forest Research Institute. These were brought to the laboratory and made into two nodal segments with the help of a saw, bearing 5-10 cm of internodal culm length at either end. A hole was made in the internodal cavity of each segment with the help of a driller. All the cuttings were made into seven homogenous lots, each consisting of five cuttings. Due care was taken not to injure the nodal buds and to maintain uniformity of the shape and size of the cuttings.

The treatments given in the months of May and August were (1) Control (2) Coumarin 10 mg/l (3) Coumarin 100 mg/l (4) NAA 10 mg/l (5) NAA 100 mg/l (6) Boric acid 10 mg/l (7) Boric acid 100 mg/l. Solutions of growth promotors were prepared by dissolving each of them separately in 5 ml of ethyl alcohol and made to two litres by adding distilled water. The hollow internodal cavity was filled with 300 ml of each solution in five replicates. In case of cutting under control, 5 ml of ethyl alcohol was diluted to 2 litres by the addition of distilled water and 300 ml of which was filled in the internodal cavity of each culm. The hole was then sealed with cellophane tape and the cuttings placed horizontally in nursery beds about 5-10 cm deep in such a way that the buds were placed laterally and the sealed hole faced upwards. These cuttings were covered with soil. Watering was done as and when needed to keep the soil moist. The nursery beds were predrenched with aldrin solution 0.1% to protect the culm cuttings from possible termite attack. The cuttings were removed from the nursery beds 180 days after planting and observations regarding sprouting, rooting and rhizome formation were recorded.

Results and Discussion

A bamboo, propagule, for successful establishment and growth, must possess well developed root system, rhizomes and shoots (Banik, 1985). The results of rooting, sprouting and rhizome formation from culm cuttings observed in the present study have been presented in Tables 1 to 3. It can be seen that the August planting showed better sprouting whereas the May planting showed better rooting. As far as rhizome development is concerned, all the treatments induced rhizome formation in May planting and only a few treatments induced rhizome formation in August planting, though the percentage of formation was better in the latter (Fig. 1)

Table 1

Average sprouting, rooting and rhizomegenesis percentages of culm cuttings of Bambusa tulda planted in May (Summer season) and August (Rainy season) under different treatments.

Treatments mg/litre	May Planting			August Planting		
	Sprouting (%)	Rooting (%)	Rhizomegenesis (%)	Sprouting (%)	Rooting (%)	Rhizomegenesis (%)
Control	20	20	20	40	20	—
Coumarin 10	40	40	40	100	—	20
Coumarin 100	40	40	40	60	20	—
NAA 10	20	20	20	60	20	60
NAA 100	20	20	20	40	—	20
Boric acid 10	40	40	20	60	—	40
Boric acid 100	40	40	20	100	—	60

Table 2

Average growth and development of shoots, roots and rhizome developed from culm cuttings after 6 months of planting.

Treatments mg/l	May Planting						August Planting					
	No. of sprouts	Length sprouts (cm)	No. of primary roots	Length primary roots (cm)	Total No. of rhizome	Volume of rhizome (c.c.)	No. of sprouts	Length sprouts (cm)	No. of primary roots	Length primary roots (cm)	Total No. of rhizome	Volume of rhizome (c.c.)
Control	16	51.2	45.0	3.52	2	40	3.5	16.34	14	4.14	—	—
Coumarin 10	5.0	66.2	18.5	5.0	3	8.5	4.1	15.1	—	—	2	12.5
Coumarin 100	3.0	39.0	17.5	6.82	3	15	5.33	21.37	5	4.50	—	—
NAA 10	1.0	55.0	8.0	3.50	1	15	3.0	41.66	1	2.0	3	11.66
NAA 100	3.0	62.0	5.0	3.60	1	5	6.0	16.29	—	—	1	15
Boric acid 10	4.0	37.0	7.0	3.57	1	20	2.66	43.40	—	—	2	8.5
Boric acid 100	2.5	34.4	6.5	2.15	1	40	10.8	4.28	—	—	3	6.66

Table 3

Average oven dry weight (gm) of shoot, root and rhizome developed from culm cuttings after 6 months of planting under various treatments.

Treatments (mg/l)	May Planting			August Planting		
	Sprout	Root	Rhizome	Sprout	Root	Rhizome
Control	3.76	.066	15.5	9 5	.07	—
Coumarin 10	4.85	.083	3.67	1.58	—	3.00
Coumarin 100	3.58	.108	6.43	1.81	.02	—
NAA 10	25.75*	.018	7.0	4.61	.01	2.67
NAA 100	6.51	.16	2.7	1.06	—	3.50
Boric acid 10	2.03	.02	5.0	2.50	—	2 75
Boric acid 100	6.23	.038	1.5	0.64	—	2.50

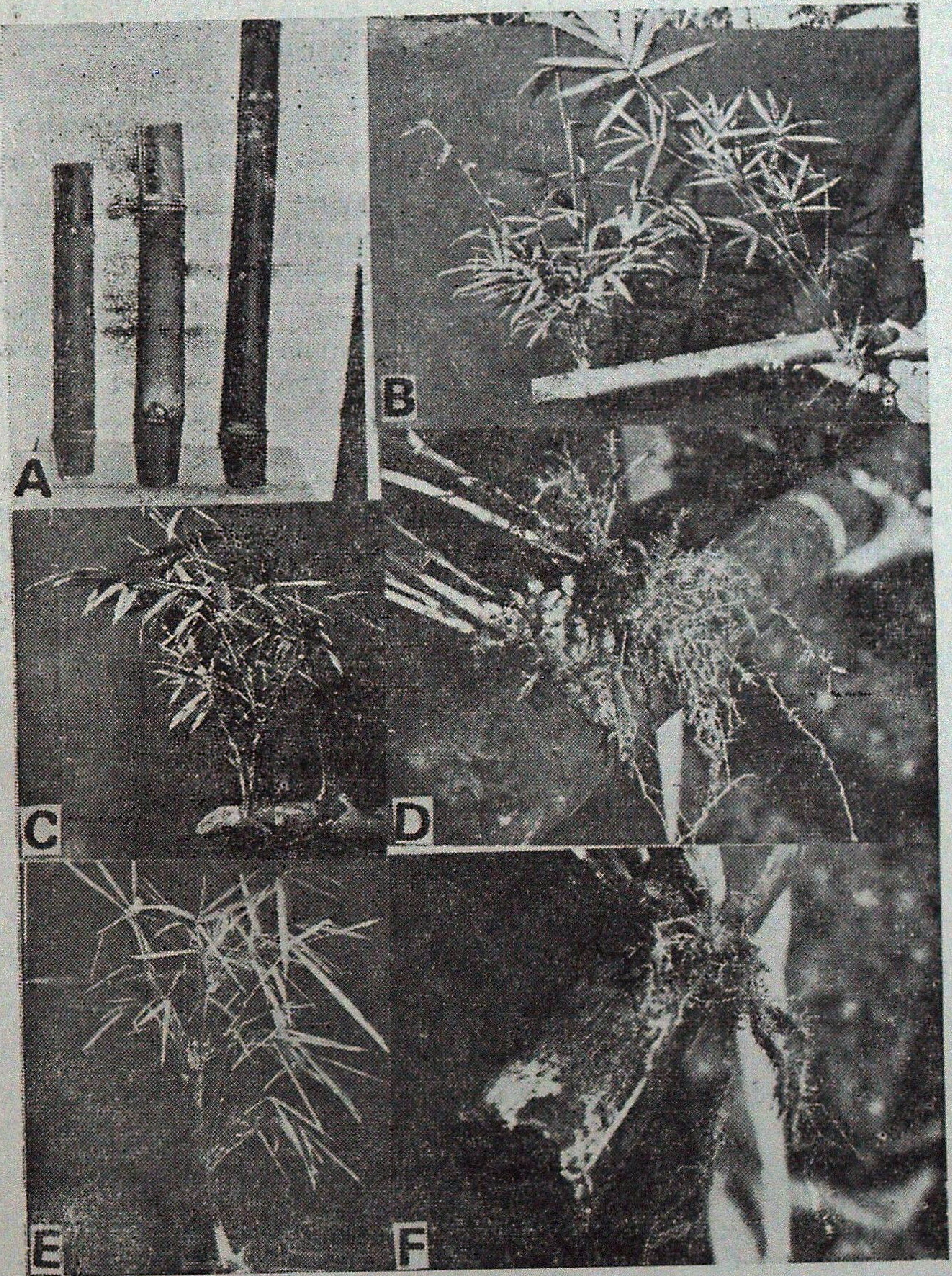
* Only one sprout developed, hence the dry weight of single sprout has been given.

The present investigation revealed that it is possible to propagate *Bambusa tulda* from culm cuttings using chemical treatments. Though earlier investigators (Seethalakshmi *et al.*, 1983, and Surendran *et al.*, 1983) reported induction of roots and shoots from *B. balcooa* and *B. arundinacea* cuttings using various chemical treatments, they have not given any indication of rhizome induction which has been displayed in this study.

The season plays a very important role in rooting and sprouting of culm cuttings in many Bamboos. In *B. tulda* also, it was noticed that the same concentration of the same chemical brought about different response in different seasons. Seasonal changes in rooting response of stem cuttings have been attributed to either change in nutritional status of the cuttings (Hartmann, 1962) or change in endogenous level of growth promoters/inhibitors (Nanda, 1970) Comparing the two seasons, dry season (May) and rainy season (August), it was found that May planting responded better.

Different species react differently for the induction of the shoots and roots. Bumarlong (1977) showed that *B. blumeana* treated with NAA gave higher total dry weight and mean number of roots, but in this investigation with *B. tulda*, Coumarin, a non-auxin and Boric acid, a readily available and a cheaper chemical, gave better response than NAA. This has also been reported for *B. arundinacea* (Surendran *et al.*, 1983). However, Liese (1985) is of opinion that in spite of intensive efforts made by various institutes, a universally applicable method for vegetative propaga-

Fig. 1



Vegetative propagation of *Bambusa tulda* under different treatments. A—Culm cuttings; B—Control; C—Coumarin 10 mg/l; D—Coumarin 100 mg/l; E—NAA 10 mg/l; F—Boric acid 10 mg/l.

tion of bamboo is not yet available. Similarly Hasan (1980), while concluding the various experiments on vegetative propagation by offset planting, branch cutting, ground layering of entire culm and aerial layering of nodes of bamboos, stated that although the bulk and the availability of branch cuttings and nodes for air or ground layering are more suitable, the success rates are less than 1%. Further, it takes 6-30 months for the planting material to become established. Roots develop in 6-12 months but the development of rhizome takes 12-36 months.

Though positive results were found in both seasons, summer season (May) planting of culm cuttings is suggested because the development of all the three essentialities i.e. sprouting, rooting and rhizome formation, have been recorded under all treatments in this season.

SUMMARY

Studies were conducted on vegetative propagation of *Bambusa tulda* by using growth promoting substances viz., Coumarin, NAA and Boric acid in 10 gm/l and 100 gm/l concentrations of each along with water treated control in summer (May) and rainy (August) seasons. Summer season (May) planting of cuttings was found better than rainy season (August) planting because the development of all the three essentialities i.e., sprouting, rooting and rhizome formation was recorded under all the treatments in May plantings.

वृद्धि प्रेरक पदार्थ उपयोग करके बैम्बुसा टुल्डा का वर्धी प्रवर्धन करना

आदर्श कुमार, मीना धवन, व बी०बी० गुप्त

सारांश

वृद्धि प्रेरक पदार्थ उपयोग में लाकर उदा० कुमारिन, एनए, और बोरिक अम्ल, प्रत्येक को 10 मिग्रा/1 और 100 मिग्रा/1 संकेन्द्रण में, और साथ में जल उपचारित नियामक रखकर, बैम्बुसा टुल्डा के वर्धी प्रवर्धन पर गर्मियों (मई) और वर्षा ऋतु (अगस्त) मौसमों में कुछ अध्ययन किये गए । गर्मियों मे (मई) कलम लगाना वर्षा ऋतु में (अगस्त) कलम लगाने से अच्छा रहा क्योंकि उनमें तीनो अनिवार्यताओं अर्थात कल्ले फूटना, जड़ें निकलना और शिफास्तम्भ बनना, इन सभी उपचारो में, मई में लगाई कलमों में अच्छा पाया गया ।

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INVESTIGATION ON THE CULM PRODUCTION AND CLUMP EXPANSION BEHAVIOUR OF FIVE BAMBOO SPECIES OF BANGLADESH

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Introduction

Unlike other members of Graminae bamboo is a complex, woody stemmed, perennial grass species. The plant has a many jointed cylindrical hollow stem, called the culm. The stems are connected to a rhizome network that spreads out horizontally beneath the soil, forming a bush known as a clump. Bamboo plays an important role in the economy specially in the rural sector of Bangladesh. Well over a thousand economic applications of this plant in the welfare of mankind has been compiled by many scientists around the world (McClure, 1967; Ueda, 1981). Bamboo grows naturally in the hilly forest lands and is also being extensively cultivated since time immemorial in the homesteads of Bangladesh. All the bamboo species of the country are medium size to tall and clump forming in nature due to their underground pachymorph rhizome system. Unfortunately a proper management system could not be developed for the commonly cultivated bamboo species of the country due to the lack of information on their culm production and clump expansion behaviour as well as other related factors. Often questions are asked by the bamboo growers—what is the planting space and at which clump age culms attain optimum height and diameter growth ? An elaborate management system has been developed (Seth, 1954; Huberman, 1959) only for *Dendrocalamus strictus* and a few other clump forming bamboo species of the subcontinent as their growth habits were studied by Deogun (1936), Kadambi (1949), Sen Gupta (1952), Krishnaswamy (1956) and other workers.

Therefore, to provide some basic information on the growth habits of common bamboo species a study was initiated during the early seventies in the central Bambusetum of Bangladesh Forest Research Institute (BFRI), Chittagong. The study was confined only on the above ground portion of five commercially important bamboo species and the results are presented in this paper.

Materials and Methods

Twenty-five offsets of *Bambusa vulgaris* Schrad. (Lacal name : Bariala, Bashnī, Baizya), *Bambusa balcooa* Roxb. (l. n. : Barobans, Barua, Barak, Valku), *Bambusa longispiculata* Gamble ex. Brandis (l. n. : Taru, Talla), and *Bambusa tulda* (l. n. : Mita, Mitinga, Makla) were collected from different localities of Bangladesh and planted in the central Bambusetum of BFRI, Chittagong in May, 1972. Similarly fifteen part-clumps (a group of 3 offsets jointed by rhizome neck) of *Melocanna baccifera* Roxb. (l.n. : Muli, Paiya) were also collected from the forests of Chittagong Hill Tract and Sylhet during May, 1972 and planted simultaneously in the Bambusetum.

The planting site was of small hills with about 30% slope facing east. The soil on the slope was sandy loam to clay loam, well drained, acidic with pH around 5.5, overlaying a loose alluvial parent materials. The land was under the influence of tropical monsoon climate having mean annual air temperature 10-35°C, soil temperature 20-23°C and total annual rainfall 2500 mm-3000 mm. Rainfall is high during the last part of May to August and dry months are from October to March.

Studies were carried out on 20 clumps in each of the four *Bambusa* species whereas 10 clumps were taken for *M. baccifera*. Full grown (FG) culms produced in all the clumps of these five bamboo species were marked every year by different coloured paints for recognizing the age of both culm (year of emergence) and clump. Measurements on the number of FG culms produced per clump culm diameter at breast height (DBH) and their length, and annual increase of the girth of each clump were measured one year after (1973) the plantation. Data were recorded every year at the end of the growth period (December) and these observations continued for subsequent ten years (from 1973 to 1982). During the study period all the clumps of these five bamboo species were allowed to grow in undisturbed condition and no felling operations were practiced.

Results and Discussion

It was observed that culm emergence in all the five bamboo species took place from May to October with maximum intensity in July. Some of the offsets planted in 1972 produced a very few culms in the later part (August-October) of the same year. However, almost every offset in each species produced culm in 1973, the next year of plantation. Since then the clumps were treated as 1-year old and recording of different growth measurements have been continued for ten years.

Culm production and clump expansion: All the five bamboo species produced only 1 to 3 full grown (FG) culms per clump in the first year after plantation (Table 1). The number of (FG) culms gradually increased in the subsequent years and became more or less maximum (3.2 to 8.8) in the 5th year of clump age in the case of all four *Bambusa* species. To provide room for the increased number of culms the rate of clump girth expansion was also rapid upto the 5th year in the case of *B. balcooa* (avg., 2.32 m) and *B. tulda* (avg., 4.39 m) and the 6th year in *B. vulgaris* (avg., 4.56 m) and *B. longispiculata* (avg., 3.7 m) after plantation (Table 1 and Fig 1). Number of FG culm production then slowly decreased from the 6th year and were 2.2 to 5.7 in the 10th year of clump age. Cumulative total of FG culms produced in the clumps of these four *Bambusa* species upto the 5th and 6th year of age made crowded condition due to short (7-12 cm) neck pachymorph rhizome system. This crowded and congested condition created a scarcity of room for the new

Table 1

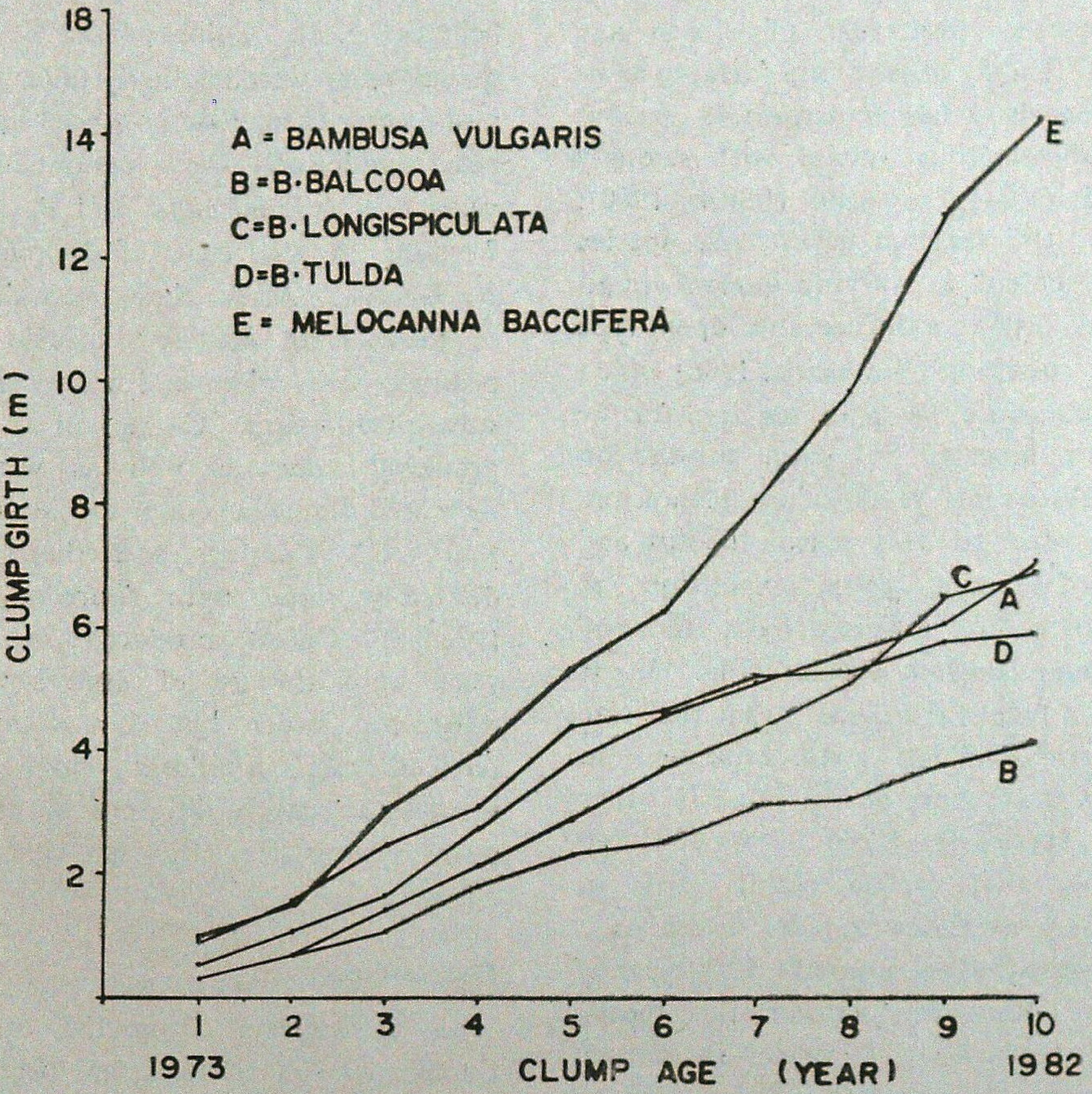
Annual full grown (FG) clump production and gradual expansion of clump girth upto 10-years of clump age in five bamboo species of Bangladesh.*

Mean value ± SE

Clump age (year)	*B. vulgaris*		*B. balcooa*		*B. longispiculata*		*B. tulda*		*M. baccifera*	
	FG culms (Nos)	Clump girth (cm)	FG clums (Nos.)	Clump girth (cm)	FG culms (Nos.)	Clump girth (cm)	FG culms (Nos.)	Clump girth (cm)	FG culms (Nos.)	Clump girth (cm)
1	1.6	50.0	1.2	28.5	1.8	30.0	3.0	87.0	2.5	92 2
(1973)	0.2	4.5	0.2	2.0	0.4	5.2	0.5	13.2	0.5	20.5
2	2.8	105.0	2.3	66.3	2.7	66.5	3.8	153.0	5.6	145 9
(1974)	0 3	10.0	0.9	13.5	0.6	13.0	0.4	16.6	1.7	23.2
3	3.2	162.6	1.7	102.0	4.1	140.2	8.2	243.0	12.5	301.0
(1975)	0 7	22.0	0.2	14 0	0.6	16.5	1.3	28.3	2.5	42.0
4	5.3	273.4	2.7	177.0	6.2	222.0	5.7	307.0	16.4	395.4
(1976)	1.2	35.5	0.4	22.6	0.5	24.7	0.9	36 5	4.2	53.3
5	5.2	378.0	3.2	232.0	7.0	286.4	8.8	439.3	23 6	529.3
(1977)	1.7	50.3	0.8	38.0	1.3	20.6	2.3	56.3	7.2	105 6
6	3.6	456.3	2.2	250.0	6.7	372.0	4 5	464.0	25.3	624.3
(1978)	0.8	62.1	0.4	29.4	1.3	28.2	1.0	51.0	4.6	115 2
7	3.2	508.3	2.4	312.5	5.0	430.0	4.9	520 1	26.6	805 4
(1979)	0.6	64.4	0.5	32.5	1.0	35.0	1.2	42.0	8.7	146.1
8	3.2	555.0	1.8	320.5	6.6	507.6	3.7	527 2	25.1	980.6
(1980)	0.6	75.8	0.5	24.0	1.4	66.6	0.3	61.6	6.2	170.5
9	2.6	603.0	2.2	376.0	5.8	648.3	4.8	571.0	31.1	1268.0
(1981)	0.6	58.0	0.5	53.7	1.0	109.6	1.8	57.6	8.0	247 0
10	2.8	705.0	2.2	414.2	5.7	690.0	2.7	586.7	35.7	1432 3
(1982)	0.7	114.5	0.5	58.3	1.6	132.3	0.4	207.8	13.3	281 0

* Clump raised through offset planting in 1972 left undisturbed upto 1983.
Note : The second row of each year are ± SE.

Fig. 1



Rate and pattern of clump expansion at different age in the five bamboo species of Bangladesh

emerging culms and also increased competition among them for survival (Kondas, 1981; Banik, 1983). Probably due to this reason culm production subsequently decreased from the 6th year in the clumps of *B. vulgaris*, *B. balcooa*, *B. longispiculata*, *B. tulda* (Table 1). Kondas (1981) observed in a clump of *B. vulgaris* planted in Dandeli, India that the culm production was higher upto the 4th year after planting and then decreased in the subsequent years. Decrease in culm production might have slowed down the rate of clump girth expansion after the 6th and 7th year in these four *Bambusa* species (Table 1 and Fig. 1). Sudden increase in the culm girth at the 9th year in the case of *Bambusa longispiculata* as shown in Fig. 1 could not be explained. In the case of *Melocanna baccifera* the average production of FG culms was 2 5 in the first year and from third year the number increased rapidly to

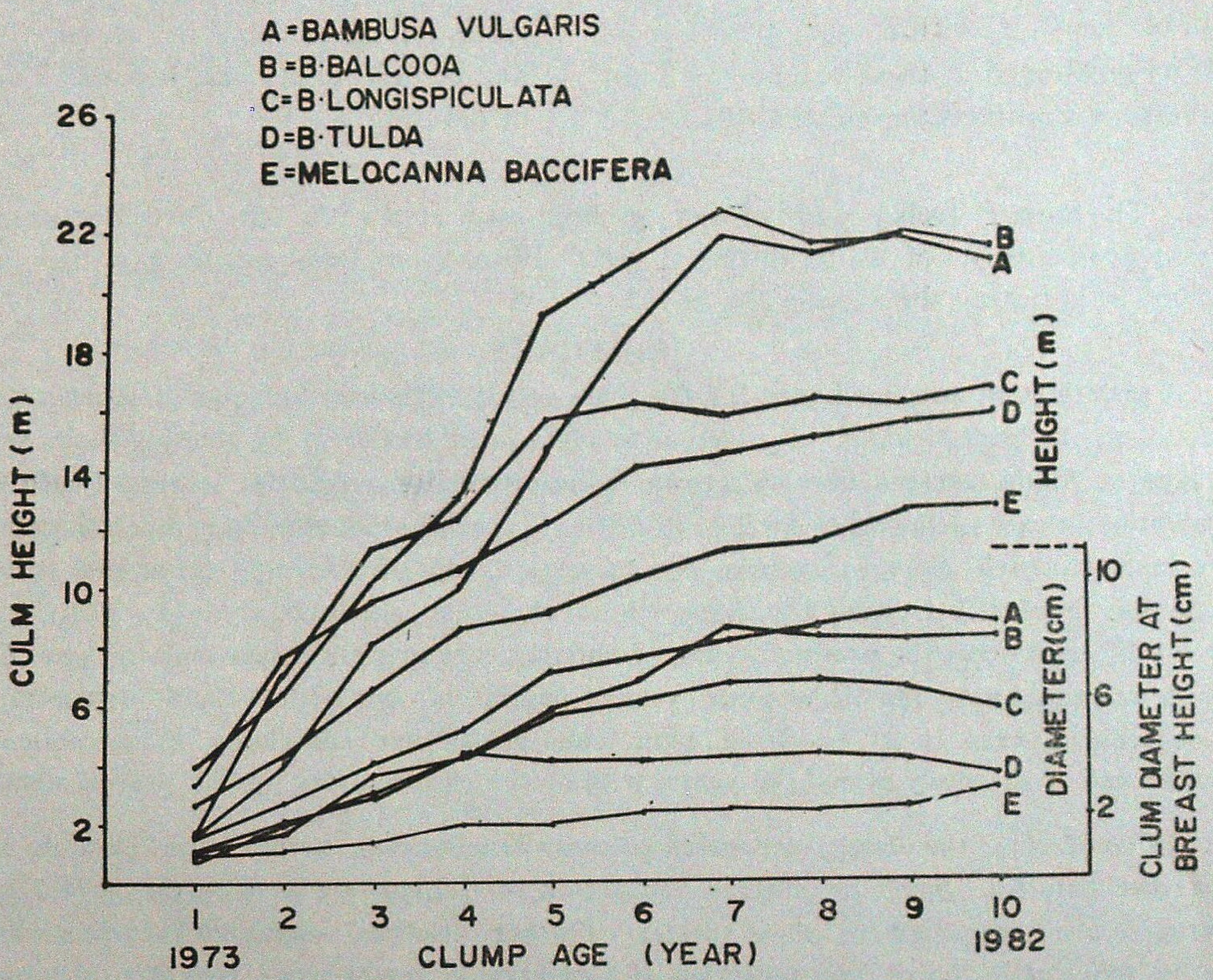
12.5. Culm production also rapidly increased in the subsequent years reaching 35.7 after the 10th year of clump age (Table 1). Unlike other clump forming bamboos *M. baccifera* has underground pachymorph rhizomatous system with strongly elongated (1.0-1.5 m) neck (Banik, 1980). Owing to this rhizome nature the species produces culms at varying intervals in all directions forming a diffuse and open type of clump condition (Watanabe, 1986) which can accommodate the space required for the increased number of FC culm production in the subsequent years after plantation. Probably due to this reason the rate and pattern of clump girth expansion in *M. baccifera* are different from those of other four *Bambusa* species (Fig. 1). It can be seen from the Figure 1 that the rate and pattern of clump girth expansion in *M. baccifera* are more or less same as other *Bambusa* species for 4 and 5 years of clump age. After that period clump girth in *M. baccifera* increased rapidly every year and continued even upto the 10th year of the study. Rhizome system of this species probably needs 4 to 5 years, in normal condition, to accumulate sufficient amount of photosynthetic reserves for producing elongated neck and as a result clump girth increased very rapidly only after that period of rhizome growth.

Culm height and diameter : Culms of all bamboo species complete their growth within 2 to 3 months after the emergence of sprouts from the ground, but their diameter and height do not increase after the growth is over (McClure, 1967; Banik, 1980; Ueda, 1981). It has been observed in all the five bamboo species that the culms emerged in the first year after plantation were short (1.5 m to 4.0 m) in length and narrow (0.7 cm to 1.6 cm) in diameter at breast height (Fig. 2). Culms produced in subsequent years were distinctly taller and wider in diameter than these produced in the past years and such trend continued upto 5-6 years in *B. longispiculata* and *B. tulda*, and 7 years in the case of *B. vulgaris* and *B. balcooa*. After these periods clumps of these four *Bambusa* species did not produce any taller and wider culms in the subsequent years Clumps of *M. baccifera* produced taller as well as wider (with increased diameter) culms in the subsequent years of planting and the trend was distinctly rapid upto four years of age (Fig. 2). Culms produced in the later years (upto 10 years of study) were also taller and wider but at a comparatively reduced rate. Similarly culm diameter was also not much different in the subsequent years after the 4th year of clump age (Fig. 2).

Conclusions

It appears from the study that number of full grown culm production in the clumps of all the four *Bambusa* species increased up the 5th year of age and then gradually decreased. Consequently to provide room for the increased number of culms, clump girth also expanded rapidly upto the 5th–6th year of age of plantation. On the average clump girth varied between 2.32 m and 4.56 m within this period depending on the species. Considering the upper limit of culms girth expansion spacing between the planting stock may be kept at least 5 m in the case of these four *Bambusa* species. In these species both the height and DBH of FG culm produced during 5 to 7

Fig. 2



Growth rate of full grown culm produced at different age in the five bamboo species of Bangladesh.

years of clump age were maximum and after that period production decreased. As the clumps were left undisturbed for a number of years a crowded and congested condition developed due to the cumulative production of culms leading to a decreased yield. Therefore selective felling of older culms should be started in these *Bambusa* species after 5 to 7 years of planting. It appears from the study that the rate and pattern of clump girth expansion in *Melocanna baccifera* are more or less same as other four *Bambusa* species upto 4 and 5 years of planting. After that clump girth expanded rapidly even upto 10th year of age. Therefore, in this species, it became difficult to prescribe any spacing for initial planting. Both height and DBH of the FG culms grown upto the 4th year increase rapidly but in the subsequent years do not have a such rapid growth.

Therefore, while with the present studyitis not possible to prescribe the first harvesting year for the species, further study is needed to find out the effect of felling after starting from the 4th year of clump age on the culm production and clump growth. It has been observed that in *M. baccifera* culms with merchantable quality are produced after four years of planting and these bamboos die out generally within next 4 to 5 years due to senescence. If these bamboos are not harvested from the clump within this period (7 to 8 years) the loss of resource would occur. Under the above consideration it seems felling of culms in *M. baccifera* may not be delayed at least beyond 7 to 8 years of planting.

Acknowledgement

The author feels proud of having been associated with Mr. Syed Martuza Hassan, retired Silviculturist of BFRI during the establishment of Bambusetum and also indebted to him for initiating the experimens in 1972.

SUMMARY

A growth study was conducted for ten years on the undisturbed clumps of *Bambusa vulgaris*, *B balcooa*, *B. longispiculata*, *B. tulda* and *Melocanna baccifera* by planting their vegetative propagules. Study revealed that full grown culm production gradually increased upto 5th year of planting in case of *Bambusa* species. In *Bambusa* species production of culms and their growth were found to reach the maximum in five to seven years of planting. After that period culm production gradually decreased and growth of the culm produced culm in subsequent years was not different than the previous years. Similarly clump girth expansion in these *Bambusa* species was rapid upto the 5th and 6th year of plantation but with reduced expansion rate in the subsequent years. In *M. baccifera* both culm production and clump expansion continued upto the end of the study period (10 years) with increased rate after the 5th year of clump age.

Considering the clump expansion pattern 5 m spacing between the planting stock is prescribed only for *Bambusa* species. Initiation of felling operation after 5 to 7 years of planting is also suggested for these species. Further study is suggested for prescribing the planting space of *M. baccifera*. Initiation of harvesting is tentatively, for this species, prescribed after 7 to 8 years of planting.

बांगलादेश की पांच बांस जातियों के सन्धिस्तम्भ उत्पादन और बीड़ा फैलने के व्यवहार का अन्वेषण

रतन लाल बनिक

सारांश

बैम्बूसा वल्गेरिस, बैं० बेल्कोआ, बैं० लांगीस्पाइक्लेटा, बे० टुल्डा और मेलोकेन्ना बैक्किफेरा के विघ्नहीन बीडो के वर्धी भाग रोपकर दस वर्षों तक उनकी वृद्धि का एक अध्ययन किया गया। इस अध्ययन से पता चला कि पूर्णता प्राप्त सन्धिस्तम्भ उत्पादन बैम्बूसा की जातियों में धीरे-धीरे रोपने के पांचवे वर्ष तक बढ़ता है। बैम्बूसा की जातियों में सन्धिस्तम्भ उत्पादन और उनकी वृद्धि रोपने से पाँच-सात वर्षों में अधिकतम पहुँच जाती है। इसके बाद सन्धिस्तम्भ उत्पादन धीरे–धीरे घट गया और बाद के वर्षों में उत्पन्न हुए सन्धिस्तम्भ पिछले वर्षो में हुए सन्धिस्तम्भों से कुछ भी भिन्न नहीं थे। इसी प्रकार इन बैम्बूसा जातियों में बीड़े की-परिधि का विस्तार रोपने के पांचवे और छटे वर्षो तक तेजी से बढ़ा परन्तु बाद के वर्षों में विस्तार की दर धट गई। मे० बैक्किफेरा में सन्धिस्तम्भ उत्पादन और–बीड़े का विस्तार दोनों अध्ययन अवधि की समाप्ति (10 वर्ष) तक चलते रहे और बीड़े की उम्र पांच वर्ष हो जाने पर विस्तार की दर बढ़ रही थी।

बीड़े के फैलने को ध्यान में रखते हुए केवल बैम्बूसा जातियों में रोपते समय बीच में 5 मीटर फासला छोड़ना प्रस्तावित किया हुआ है। इन जातियों में रोपने के 5 से 7 वर्षों के पश्चात् पातन चक्र आरम्भ करना भी सुझाया हुआ है। मे० बैकफेरा लगाते समय फासला कितना रखा जाय, इसे निर्धारित करने के लिए और अध्ययन किया जाना चाहिए। फसल कटाई का आरम्भ भी इस जाति के लिए अन्तरिम रूप से ही रोपने के 7 से 8 वर्ष के बाद निर्धारित किया हुआ है।

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EFFECT OF NUTRIENTS ON THE GROWTH BEHAVIOUR OF *BAMBUSA TULDA* IN THE NURSERY

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Introduction

The bamboos are widely distributed through out India and considered the world's largest reserves (Bamboo Research in Asia, 1980). The bamboos occupy an area of about 9.57 m ha consisting of 20 genera and more than 100 species. They have numerous uses in Indian economy and provide raw material for rayon and paper industries (Suri and Chauhan, 1984). *Bambusa tulda* is found mainly in East India and cultivated in the plains and foot hills of North India. The species generally attains a height of 21 m under favourable conditions, branching freely from nearly all the nodes, the branches from the lower nodes being thin and more or less horizontal. It is characteristically gregarious in the wild state.

Keeping in view the socio-economic importance of *Bambusa tulda*, an experiment was laid out in the nursery beds of Silviculture Branch at Forest Research Institute, Dehra Dun to study the effect of N and P on its growth behaviour. The valuable information obtained from this experiment is presented in this paper.

Material and Methods

The New Forest soil and Rispana sand were mixed together in the ratio of 1:1 for the experiment. Approximately 2 kg soil sand mixture was filled in perforated polythene bags which were arranged in batches of 49 bags for each treatment in completely randomised design. Treatments consisted of 3 levels of nitrogen (0, 50 and 100 ppm N as urea designated N_0, N_{50} and N_{100} respectively), 3 levels of phosphorus (0, 50 and 100 ppm P_2O_5 as super phosphate designated P_0, P_{50} and P_{100} respectively) and 7 dates of application ($T_1 = 4$ weeks, $T_2 = 6$ weeks, $T_3 = 8$ weeks, $T_4 = 4$ and 6 weeks, $T_5 = 4$ and 8 weeks, $T_6 = 6$ and 8 weeks and $T_7 = 4$, 6 and 8 weeks after germination) in all factorial combinations. To provide 50 or 100 ppm nutrients, 10 or 20 ml of 1.6% urea solution or 7.5% super phosphate suspension; respectively were added. In case of T_1, T_2 and T_3 treatments, full amount was added in one dose whereas in case of T_4, T_5 and T_6 total amount was added in two equal doses and in case of T_7 in three equal doses.

Bambusa tulda seeds of uniform size were sown in each polythene bag on 22nd Feb., 1988 and were monitored for their germination percentage. Observation and growth parameters were recorded at regular intervals. The seedlings were uprooted 17 weeks after germination and their tiller number, leaf number, collar diameter and root, shoot weights were recorded. The data so collected were statistically analysed.

Relative height growth rate was calculated by the formula RGR = 100 × (Present height—Initial height)/Initial height (Raina, *et al.*, 1988), where initial height was noted 3 weeks after germination.

Results

Germination : The seeds of *Bambusa tulda* started germinating after 4 weeks and was 39% after 5 weeks of sowing and increased to 59%, 63% and 69% after 6, 7 and 8 weeks. It may be noted that *Bambusa tulda* seeds took 6 to 7 weeks for complete germination. Pre-soaking of seeds before sowing in the polybags may have reduced the period of germination.

Plant height : There was increase in height growth of *B. tulda* seedlings after 17 weeks from germination from 36.61 cm in control to 53.94 cm in N_{00} P_{100} treatment, an increase of 47% (Table 1). Among the nutrients, application of nitrogen enhanced the height growth more than phosphorus application.

It was also observed that height growth due to single nutrient application after 6 weeks of seed germination was relatively more effective than 4 or 8 weeks after seed germination (Table 2). Split application of nutrients in equal quantity after 6 and 8 weeks resulted in highest height growth.

Tiller number : There was a greater response to N application than P application in increasing tiller numbers. Tillers increased from 4.61 in N_0 to 6.51 in N_{100} treatment and was statistically significant, whereas P application has no significant effect on tiller number and changed from 5.4 in P_0 to 5 7 in P_{100} treatment. There was an increase of 54% in N_{100} P_{100} (6.73) treatment from N_0 P_0 (4.36) treatment.

Application of nutrients 6 weeks after germination was significantly superior to 4 week application and at par with 8 week application when nutrients were applied only once (Table 2). Nutrient application in two split doses of 4 weeks and 8 weeks after germination was better than when applied 4 and 6 weeks or 6 and 8 weeks after germination. The highest number of tillers were recorded, however, when nutrients were applied in three split doses 4, 6 and 8 weeks after germination.

Leaf number : Application of nitrogen and phosphorus alone or in combination increased leaf number and was highest (45.84) in N_{100} P_{100} treatment. Application of nitrogen increased from 31.34 in no nitrogen treatments to 44.32 in 100 ppm nitrogen applications and was statistically significant at 1% level. Application of phosphorus increased from 35.83 in no phosphorus treatments to 38.89 in 50 ppm phosphorus applications and was significant at 5% level.

Similar to tiller number, application of nutrients 6 weeks after germination was superior when applied in single dose. When applied in two split doses, application of nutrients 4 and 8 weeks after germination was superior whereas nutrient application in three split doses resulted in highest leaf number of 44.12 and was statistically superior to T_1, T_2, T_3, T_4 and T_6 treatments.

Collar diameter : Application of nitrogen alone significantly increased collar diameter from 1.80 (no nitrogen treatments) to 1.97 mm (100 ppm nitrogen treatments).

Table 1

Effect of nutrient application on different growth parameters of Bambusa tulda seedlings.

	Height (cm)	Tiller number	Leaf number	Collar Dia (cm)	Biomass (g/plant)		
					Shoot	Root	Total
N_0 P_0	36.61	4.36	28.73	1.73	1.88	1.06	2.94
N_0 P_{50}	43.42	4.90	34.04	1.78	2.57	1.25	3.82
N_0 P_{100}	46.11	4.57	31.26	1.89	2.88	1.38	4.26
N_{50} P_0	42.66	5.53	35.90	1.84	2.60	1.28	3.88
N_{50} P_{50}	44.57	5.44	38.40	1.84	3.46	1.57	5.03
N_{50} P_{100}	47.15	5.79	39.26	1.75	3.30	1.48	4.78
$N_{100}P_0$	49.62	6.31	42.87	1.98	4.32	2.07	6.39
$N_{100}P_{50}$	49.26	6.46	44.24	2.00	4.71	2.30	7.01
$N_{100}P_{100}$	53.94	6.73	45.84	1.92	5.07	2.24	7.31
				Average of Nitrogen			
N_0	42.05	4.61	31.34	1.80	2.44	2.16	3.67
N_{50}	44.79	5.59	37.85	1.81	3.12	2.52	4.56
N_{100}	50.94	6.50	44.32	1.97	4.70	2.86	6.90
				Average of Phosphorus			
P_0	42.96	5.40	35.83	1.85	2.93	2.57	4.40
P_{50}	45.75	5.60	38.89	1.88	3.58	3.00	5.29
P_{100}	49.06	5.70	38.79	1.85	3.75	2.97	5.45
			Critical difference (1% level of significance)				
N or P	4.43	0.48	3.10	0.09	0.41	0.21	0.59
N × P	7.68	N.S	4.08	0.11	0.72	0.28	1.03

Application of P_2O_5 alone had no significant effect on collar diameter but when applied with N, there was significant (5% level) increase in collar diameter and was maximum (2.00 mm) in N_{100} P_{50} treatment an increase of 14% over control.

Among the various time of nutrient application T_2 was significantly superior to treatment T_3 and at par with T_1 treatment. Among the split applications treatment T_4 (nutrient application 4 and 6 weeks after germination) was significantly superior to treatment T_5 and at par with treatments T_6 and T_7.

Shoot biomass : Application of nitrogen and phosphorus alone or in combination increased shoot biomass significantly. There was an increase of 93% shoot biomass from

Table 2

Effect of time of nutrient application on different growth parameters of Bambusa tulda seedlings.

	Height (cm)	Tiller number	Leaf number	Collar Diameter (mm)	Biomass (g/plant)		
					Shoot	Root	Total
T_1	42.03	4.78	33.19	1.81	2.80	1.37	4.17
T_2	44.69	5.67	37.56	1.92	3.35	1.60	4.95
T_3	43.09	5.24	35 70	1.78	3.23	1.66	4.89
T_4	47.07	5.39	35.72	1.97	3.20	1.53	4.73
T_5	48.15	6.12	41.42	1.75	3.51	1.56	5.07
T_6	49.31	5.30	37.16	1.88	3.32	1.45	4.77
T_7	47.14	6.46	44.12	1.90	4.52	2.22	6.74
C.D 5%	N.S	0.74	4.73	0.13	0.63	0.32	0.90

no nitrogen treatments (2.44 g/plant) to 100 ppm N treatments (4 70 g/plant). On the other hand increase due to P application was only 28% from no phosphorus treatments (2.93 g/plant) to 100 ppm P_2O_5 treatments (3.75 g/plant). The highest shoot biomass was recorded in N_{100} P_{100} treatment (5.07 g/plant) (170% more than N_0 P_0 treatment) and was statistically higher than all treatments except N_{100} P_{50}.

Among the single nutrient application treatments, 6 weeks application was the best. Among the split applications, treatments T_7 (4.52 g/plant) was the highest and significantly superior followed by T_5 (3.51 g/plant), T_2 (3.35 g/plant).

Root biomass : Similar to shoot biomass, root biomass was also affected by the application of N and P fertilizers applied either alone or in combination. However highest root biomass (2.30 g/plant) was recorded in N_{100} P_{50} treatment which was 117% more than the N_0P_0 treatment and was statistically at par with $N_{100}P_0$ and N_{100} P_{100} treatments. Root biomass increased from 2.16 g/plant in no nitrogen treatments to 3.86 g/plant in 100 ppm N treatments. In 50 ppm P_2O_5 treatments root biomass increased from 2 57 g/plant (no phosphorous treatments) to 3.00 g/plant an increase of only 14%.

Root biomass increased when total nutrients were applied 8 weeks after germination (T_3) was superior to other applications (T_1, T_2, T_4, T_5 and T_6) except T_7. Three split applications was significantly superior to all other applications and was 2.22 g/plant.

Total biomass : Application of nitrogen and phosphorus alone or in combination increased total seedling biomass at 1% level of significance. The increase in total biomass was much greater (88%) due to N treatments than phosphorus treatments

(24%). The total dry biomass increased from 3.67 g/plant in no nitrogen treatments to 6.90 g/plant in 100 ppm N treatments whereas 4.40 g/plant was recorded in no phosphorus treatments to 5.45 g/plant in 100 ppm P_2O_5 treatments. The highest total bioamss (7.31 g/plant) was recorded in N_{100} P_{100} treatment as compared to 2.94 g/plant in N_0 P_0 treatment and was 150% more and was statistically at par with only N_{100} P_{50} and N_{100} P_0 treatments.

When nutrients were applied only once, 6 week application (T_2) was the best (4.95 g/plant). However, two split applications of 4 and 8 weeks after germination (T_5) was superior to T_2 treatment. Three split applications (T_7) was the best treatment (6.74 g/plant) and was statistically superior to all other treatments at 1% level of significance.

Discussion

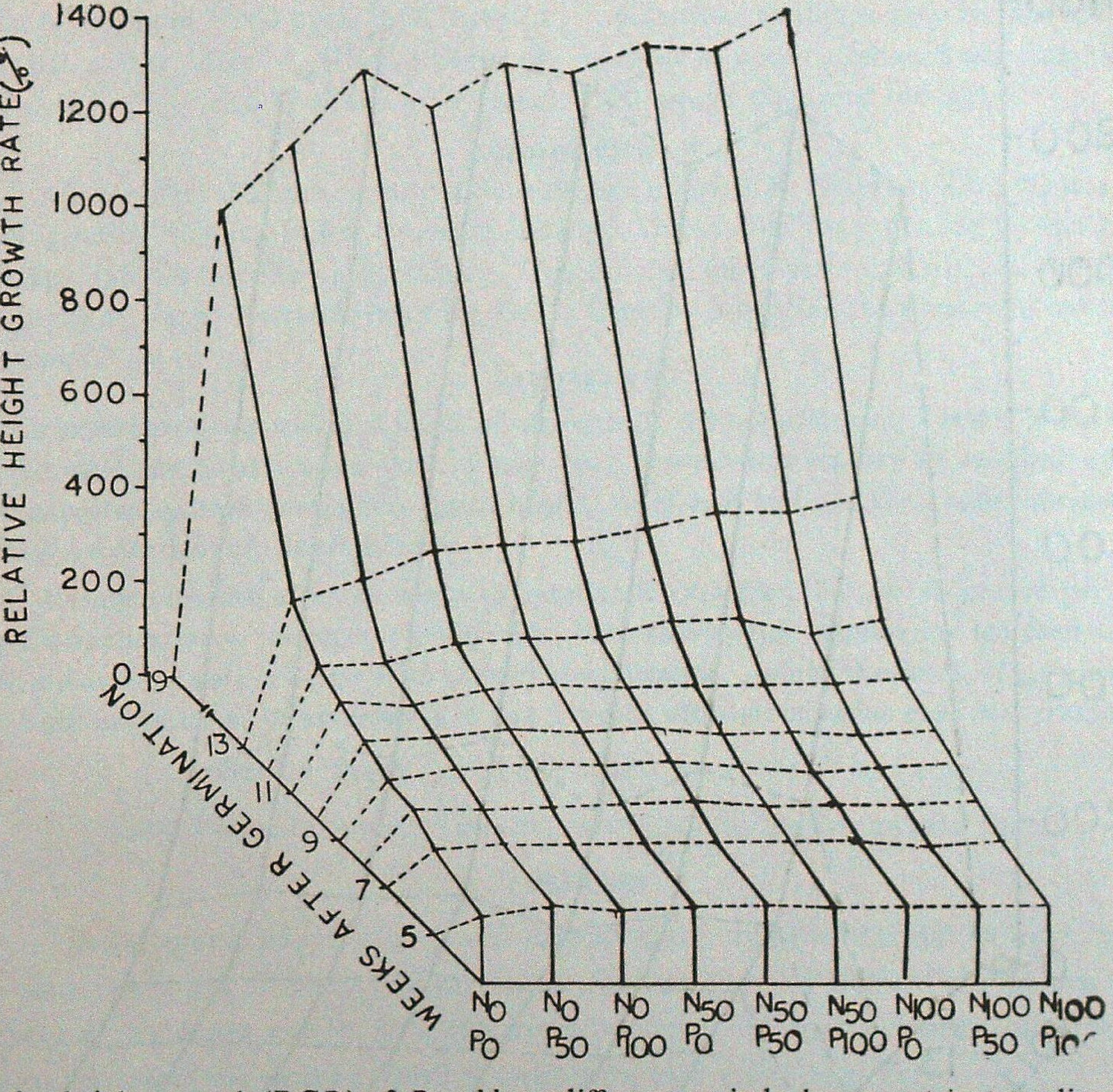
In general nitrogen application increased height, tiller number, leaf number, collar diameter, shoot weight, root weight and total weight than phosphorus application. Increase due to N treatments for all parameters were statistically significant at 1% level. In case of phosphorus application, leaf number and collar diameter decreased when 100 ppm P_2O_5 were applied as compared to 50 ppm P_2O_5 treatments. Further only shoot, root and total biomass was statistically significant at 1% level when phosphorus was applied. Interaction effect of N and P was not significant in case of height and tiller number and was significant only at 5% level for leaf number and collar diameter.

A perusal of Fig. 1 may reveal that there was no appreciable difference in the RGR upto 10 weeks after germination. In the 11th week there was an increase in the RGR of treatment N_0 P_{100} over N_0 P_0 and N_0P_{50} which continued till the period of study and was highest after 19 weeks of germination. On the other hand when N_{50} was applied there was an increase in RGR due to P application after 12 weeks of germination. In all cases there was a gradual increase in RGR due to nitrogen application coupled with phosphorus application and was highest in treatment N_{100} P_{100} from 11 weeks onward which further confirm that N_{100} P_{100} is the best treatment.

In the present study application of nutrients in three split doses after 4, 6 and 8 weeks of germination or 9, 11 and 13 weeks after seed sowing resulted in maximum number of tillers and leaves and highest shoot, root and total biomass The next best nutrient application was in two split doses after 4 and 8 weeks of germination or 9 and 13 weeks after seed sowing with regard to tiller number, leaf number and root, shoot and total biomass. Among the single dose 6 week application seems to be the best with regard to all the parameters studied except root biomass. Raina *et al.* (1988) reported increased height growth due to N and P application either alone or in combination when nutrients were applied once in two weeks.

The RGR values as affected by the time of nutrient application started showing its effect only after 9 weeks of germination (Fig. 2). Among the single dose of nutrient application treatment T_2 was higher than T_1 and T_3 throughout the period of

Fig. 1

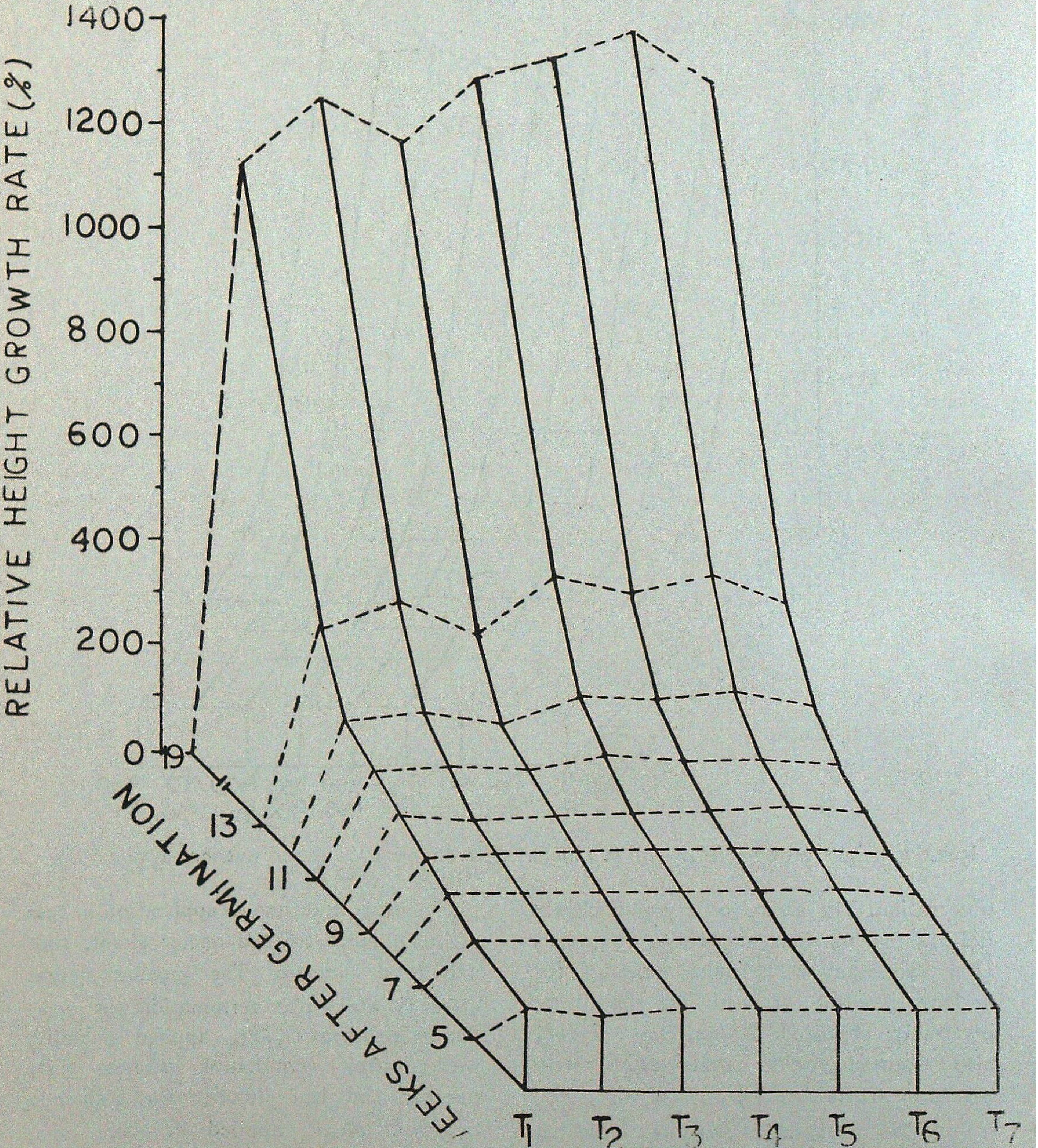


Relative height growth (RGR) of *B. tulda* at different periods due to nutrient application.

observation. The above observation clearly indicate that nutrient application 6 weeks after germination is most essential for healthy seedling growth and should be invariably practised. Raina, *et al.* (1988) also reported similar observations with regard to *Acacia catechu.*

The statistical analysis indicated significant relationship between nitrogen levels and time of application, phosphorus levels and time of application and nitrogen, phosphorus and time of application in case of leaf number, collar diameter, shoot, root and total biomass. The greatest height after 19 weeks after germination was recorded in treatment $N_{100}P_{100}$ applied 6 and 8 weeks after germination whereas tiller number and leaf number was highest in treatment $N_{.06}P_0$ applied in three split doses. However, collar diameter, shoot, root and total biomass was highest at $N_{100}P_{50}$ treatment applied in three split doses.

Fig. 2



Relative height growth (RGR) of *B. tulda* at different periods due to time of nutrient application.

Conclusion

Therefore, the study suggests application of 100 ppm N, 50 ppm P_2O_5 applied in equal doses after 4, 6 and 8 weeks of germination (9, 11 and 13 weeks after seed sowing) for greater vigour, and early plantable seedlings. Using this method plantable seedlings may be available from 14 to 16 weeks after seed germination (18 to 20 weeks after seed sowing).

Acknowledgement

Authors feel pleasure to extend their thanks to Dr. S.P. Banerjee; Coordinator, Forest Soil-Vegetation Survey, Forest Research Institute, Dehra Dun for providing all facilities and showing interest during experiment. Thanks are also due to Assistant Silviculturist (Resrarch) of Forest Research Institute, Dehra Dun for providing the nursery to conduct the experiment.

SUMMARY

An experiment comprising 3 levels of nitrogen (0, 50 and 100 ppm) 3 levels of P_2O_5 (0, 50 and 100 ppm) and 7 application dates of each, was conducted in nursery to see their effect on some important growth parameters (plant height, tiller and leaf number, collar diameter and biomass production) of *Bambusa tulda*.

Results recorded after 17 weeks of germination revealed that for all growth parameters, separate application of nitrogen was superior than phosphorus application but their combined applications were always better than individual application. Among the doses, $N_{100}P_{50}$ was found best. Split applications of nutrients 4, 6 and 8 weeks after germination gave best results.

रोपणी में बैम्बूसा टुल्डा के वृद्धि व्यवहार पर पोष्याहारों का प्रभाव

ए०के० रैना, के०जी० प्रसाद, एस०सी० फरासी, के०एस० कपूर व एस०बी० सिंह

सारांश

बैम्बूसा टुल्डा के कतिपय वृद्धि परिमापों (पौधे की ऊचाई, प्ररोहक और पत्तियों की संख्या, मूल संधि पर व्यास और जैवपुंज उत्पादन) पर नाइट्रोजन के तीन स्तर (0, 50 व 100 भाग प्रति दस लाख पानी में मिलाकर) पी$_2$ ओ$_5$ के तीन स्तर (0, 50 व 100 भाग प्रति दस लाख भाग पानी में मिलाकर) और प्रत्येक को सात बार देना रखकर एक संपरीक्षण रोपणी में उनका प्रभाव देखने के लिए किया गया।

अंकुरण के 17 सप्ताह पश्चात अभिलिखित किए गए परिणामों से पता चला है कि सभी वृद्धि परिमापों के लिए नाइट्रोजन को अलग से देना फास्फोरस देने से बेहतर है परन्तु दोनों को मिलाकर देना उन्हें अलग-अलग देने से सर्वदा अच्छा रहता है प्रयुक्त मात्राओं में नाइट्रोजन 100 फास्फोरस 50 सर्वोत्तम रही। पोष्याहारों को विभक्त करके अंकुरण हो जाने के 4, 6 और 8 सप्ताह बाद देने से सर्वोत्तम परिणाम प्राप्त हुए।

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EFFECT OF NITROGEN AND PHOSPHORUS FERTILIZATION ON *DENDROCALAMUS STRICTUS* SEEDLINGS

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Introduction

Bamboo is regenerated by various vegetative methods (Nath *et al.*, 1986) and by sowing seeds. In vegetative propagation, the physiological cycle of the bamboo has to be known precisely. Baule and Fricker (1970) while discussing on "Pre-requisites for the fertilizer treatment of forest nurseries" mention that it is precisely the vigorous plants which over come the shock of transplanting more quickly and more effectively. In every respect they are more resistant than the stunted planting material raised on sites deficient in nutrients.

In view of the above, the present study was taken up to examine the effect of Nitrogen and Phosphorus fertilizers on the seedlings of *Dendrocalamus strictus* so as to enable them to withstand more adverse conditions of poor afforestation sites. These seedlings will definitely have much more reserve food material in the rhizomes to get along for longer time till they establish and throw out more roots in search of food material.

Materials and Methods

A pot experiment was conducted for a period of 5 months in 1986 for which surface soil (0-15 cm) from R.F.R.C. Campus, Jabalpur was collected. After air drying the same was passed through 2 mm sieve and 2 kg soil (Typic Chromoustert) (Totey and Prasad, 1986) was filled in polybags. The following treatments were used in factorial R.B.D. (3×3) design with 4 replications.

N	in terms of gm urea in 2 kg soil	0.0, 5.0, 10.0
P	in terms of gm super phosphate in 2 kg soil	0.0, 10.0, 20.0
K	in terms of gm muriate of potash in 2kg of soil	20.0, 20 0, 20.0

Above fertilizers were thoroughly mixed up with 2 kg soil before filling the polybags.

The important physico-chemical properties of soil are as below :

Physical properties : Sand—32.8%
Silt —33.2%
Clay—34.0% } Clay loam
Chemical properties: pH — 7.2
E.C — 0.172 mm hos/cm
O.C — 1.29%

One week old germinated bamboo seeds of *D. strictus* were transplanted in treated polybags with two seeds in each bag.

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Watering was done at regular interval to maintain soil moisture. After every month measurements like height, fresh weight. girth and length of rhizome were recorded. After 5 months all the plants were uprooted carefully; separated into leaves, roots, culms and rhizomes and were oven dried at 60°C for 48 hours. The dry weights were also recorded. The statistical analysis was done following Steel and Torrie (1960).

Results and Discussion

The growth data viz. average height, number of culms/ plant, length of rhizomes and girth of rhizome are presented in Table 1.

Table 1

Effect of N and P fertilization on the growth of Bamboo (Dendrocalamus strictus).

	P_0	P_{10}	P_{20}	Mean	C.D for N		C.D. for P		C.D. for N×P	
					5%	1%	5%	1%	5%	1%
	1	2	3	4	5	6	7	8	9	10
Average height at 90 days (in cm)										
N_0	18.12	22.40	29.20	23.24						
N_5	14.52	15.57	19.40	16.49						
N_{10}	14.72	18.05	18.20	16 99						
Mean	15.78	18.67	22.26	—	7.80	10.57	7.80	NS	NS	NS
Average height after 120 days (in cm)										
N_0	40.62	41.22	49.75	44.09						
N_5	25.87	28.75	35.37	29.99						
N_{10}	19.25	22.62	27.65	23.17						
Mean	28.58	31.09	37.59	—	13.79	18.68	NS	NS	NS	NS
Average height after 150 days (in cm)										
N_0	58.50	59.00	69.05	62.18						
N_5	47.20	51.47	53.65	50.77						
N_{10}	32.67	39.73	39.50	37.30						
Mean	46.12	50.06	54.06	—	18.72	25.36	NS	NS	NS	NS
Average number of culms/plant at 90 days										
N_0	2.50	2.87	3.00	2.79						
N_5	1.37	1.62	1.75	1.58						
N_{10}	1.25	1.25	1.75	1.41						
Mean	1.70	1.91	2.16	—	0.86	1.17	NS	NS	NS	NS

(Contd...)

	1	2	3	4	5	6	7	8	9	10
				Average number of culms/plant at 120 days						
N_0	3.37	3.25	3.00	3.20						
N_5	2.75	2.00	1.75	2.16						
N_{10}	2.75	2.12	1.87	2.24						
Mean	2.95	2.45	2.20	—	1.197	1.622	NS	NS	NS	NS
				Average number of culms/plant at 150 days						
N_0	4.12	3.75	3.37	3.74						
N_5	2.75	2.50	2.25	2.50						
N_{10}	2.75	2.75	2.50	2.66						
Mean	3.20	3.00	2.70	—	1.11	1.51	NS	NS	NS	NS
				Average length of rhizome (in cm)						
N_0	6.02	7.30	7.75	6.92						
N_5	4.85	5.64	6.20	5.57						
N_{10}	3.90	4.05	4.15	4.03						
Mean	4.92	5.67	5.93	—	1.65	2.23	NS	NS	NS	NS
				Average girth of rhizome (in cm)						
N_0	3.10	3.55	3.30	3.31						
N_5	1.90	2.50	2.30	2.23						
N_{10}	1.30	2.12	1.95	1.79						
Mean	2.10	2.72	2.51	—	1.17	1.59	NS	NS	NS	NS

Application of urea adversly affect growth characters over control. The height of plant, number of culms/plant, length and girth of rhizomes calculated after 90, 120 and 150 days were found to be maximum in N_0P_0 treatment i.e. control (Fig 1-3). Application of urea, followed by its increased doses significantly decreases the yield of these parameters. This may be attributed to high concentration of soluble fertilizer urea. Cereals receiving excess nitrogen have also been shown to exhibit lodging as a result of the decreased thickness of cell walls or owing to the poor development of mechanical tissues of stem or both (Kanwar, 1976). Adverse effect of excess nitrogen on the growth characters in *Populus* species has also been reported (Deol and Khosla, 1983).

Application of phosphorus increased all growth parameters of bamboo recorded at 90, 120 and 150 days (Table 1). Number of culms/plant showed increase with increasing level of phosphorus upto 90 days but thereafter the number of culms decreased slightly with the increase of P level. The length and girth of rhizome were found to increase over control with increasing dose of P. The maximum girth of rhizome was found at P_{10} where as maximum length was at P_{20}. There is definite tendancy of increase in growth parameters with the application of 'P' however they are statistically non-significant (Fig. 1-3). Phosphorus being an essential constituent of several enzymes and co-enzymes which are involved in basic reactions of photosynthesis, it is assumed that phosphate had a specific action on encouraging root development (Russell, 1975).

Interaction of N and P was not significant in none of the cases.

In case of dry matter production, it is apparent (Table 2, Fig. 4). that the application of urea significantly decreased the yield of leaves, culms roots and rhizomes. This adverse effect may be attributed to higher N dose. In higher N conditions, carbohydrates are rapidly converted into proteins and smaller proportion is left for cell was material giving rise to thin walled cells (Russell, 1975).

Table 2

Effect of N and P fertilization on dry matter yield (in cm) pot of bamboo

	P_0	P_{10}	$P_{\ 0}$	Mean	C.D. for N		C.D. for P		C.D. for N × P	
					5%	1%	5%	1%	5%	1%
		Leaf :								
N_0	2.98	4.41	5.78	4.35						
N_5	1.43	2.11	3.31	2.28						
N_{10}	1.33	1.44	1.44	1.40						
Mean	1.91	2.62	3.51	—	2.27	3.07	NS	NS	NS	NS
		Culms :								
N_0	2.86	4.06	9.26	5.39						
N_5	1.42	2.05	3.69	2.38						
N_{10}	1.25	1.40	1.40	1.35						
Mean	1.84	2.50	4.78	—	2.88	3.91	2.88	3.91	NS	NS
		Root :								
N_0	0.75	1.20	1.92	1.29						
N_5	0.35	0.52	0.73	0.53						
N_{10}	0.21	0.35	0.42	0.32						
Mean	0.43	0.69	1.02	—	0.693	0.939	0.693	NS	NS	NS
		Rhizome :								
N_0	1.08	1.70	3.57	2.11						
N_5	0.55	0.72	1.70	0.99						
N_{10}	0.44	0.46	0.56	0.48						
Mean	0.69	0.96	1.94	—	1.06	1.48	1.06	1.43	NS	NS

Fig. 1

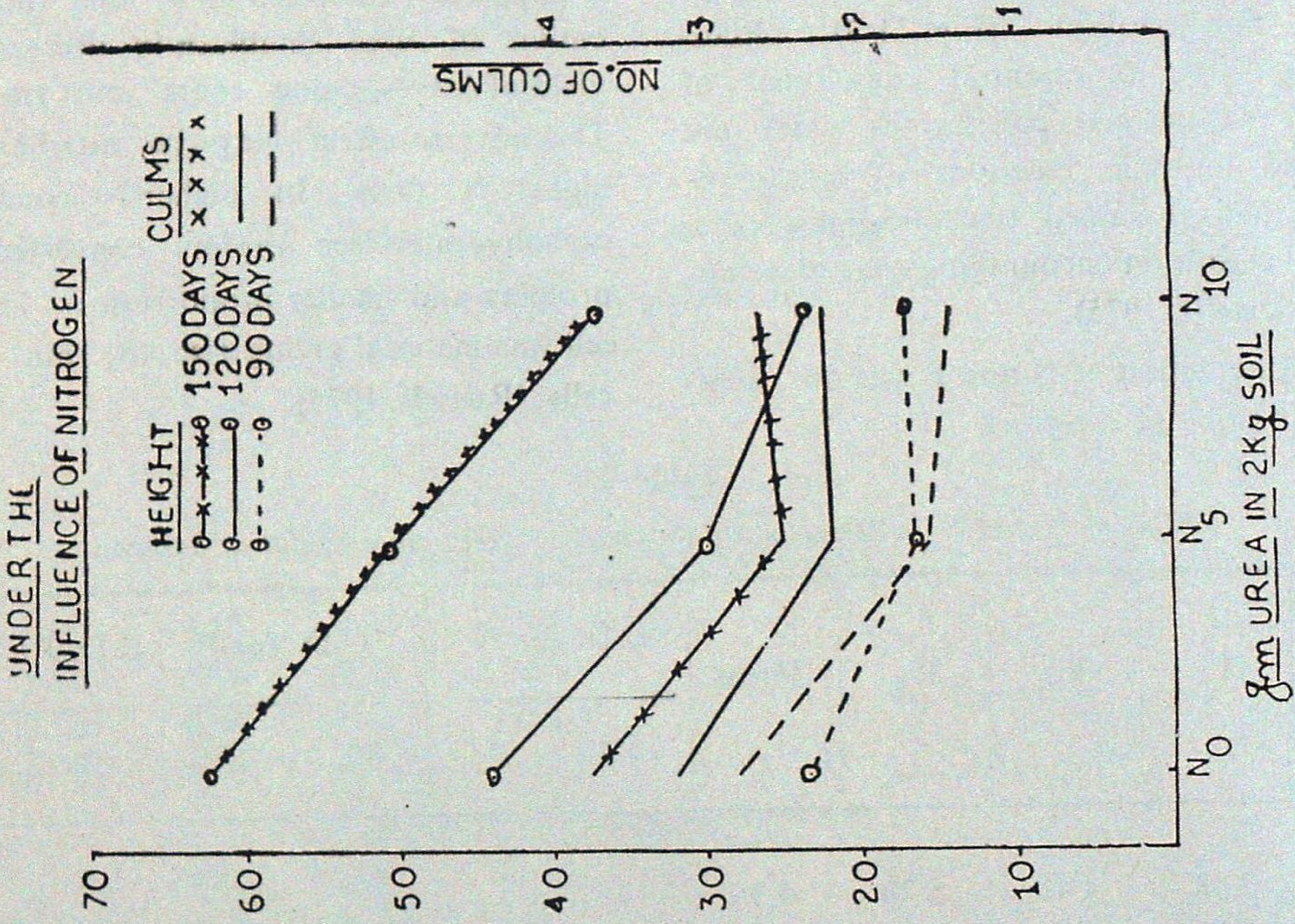
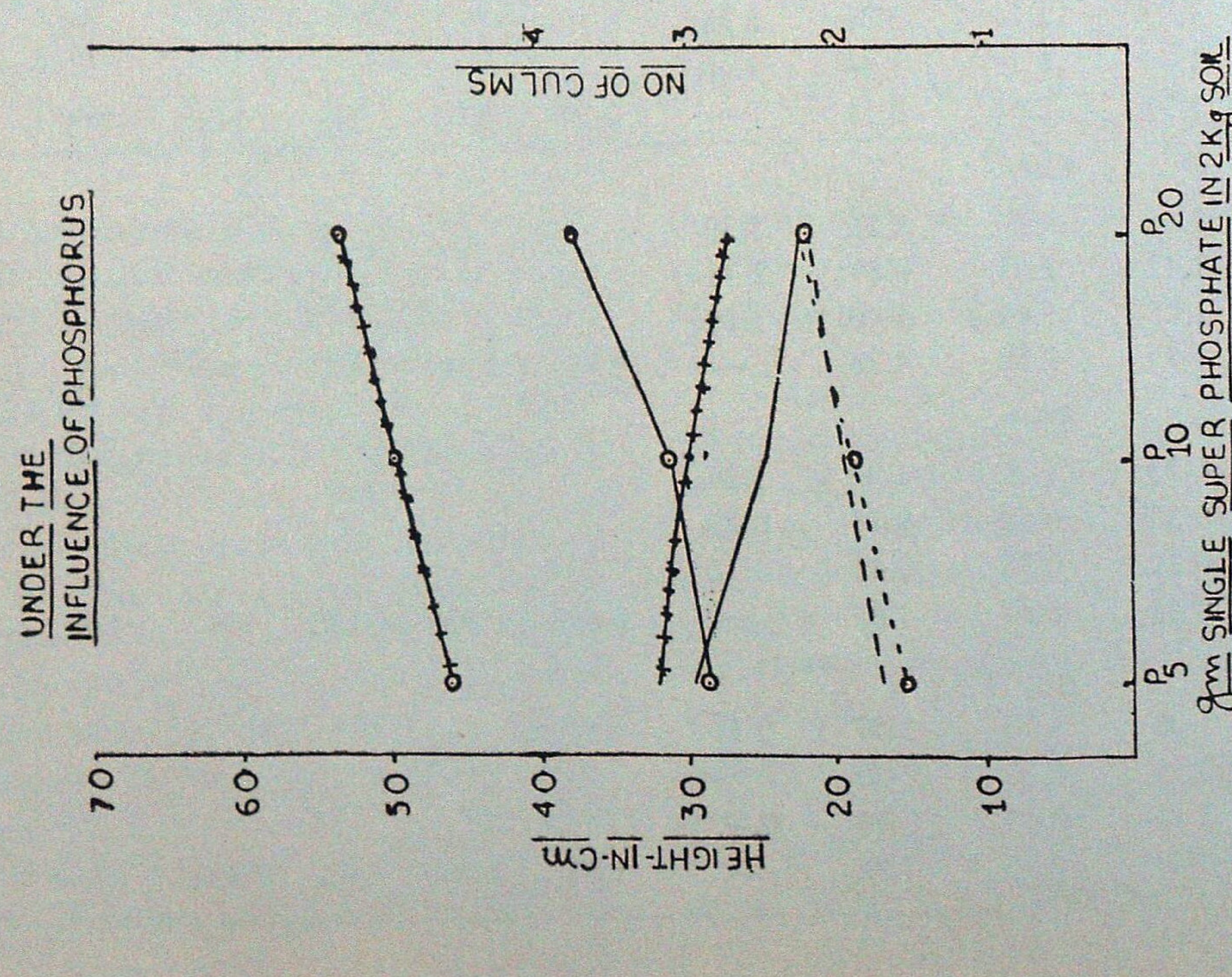


Fig. 2



Mean height of bamboo seedlings and number of culms/bamboo seedlings at different intervals.

Fig. 3

Under the influence of Nitrogen

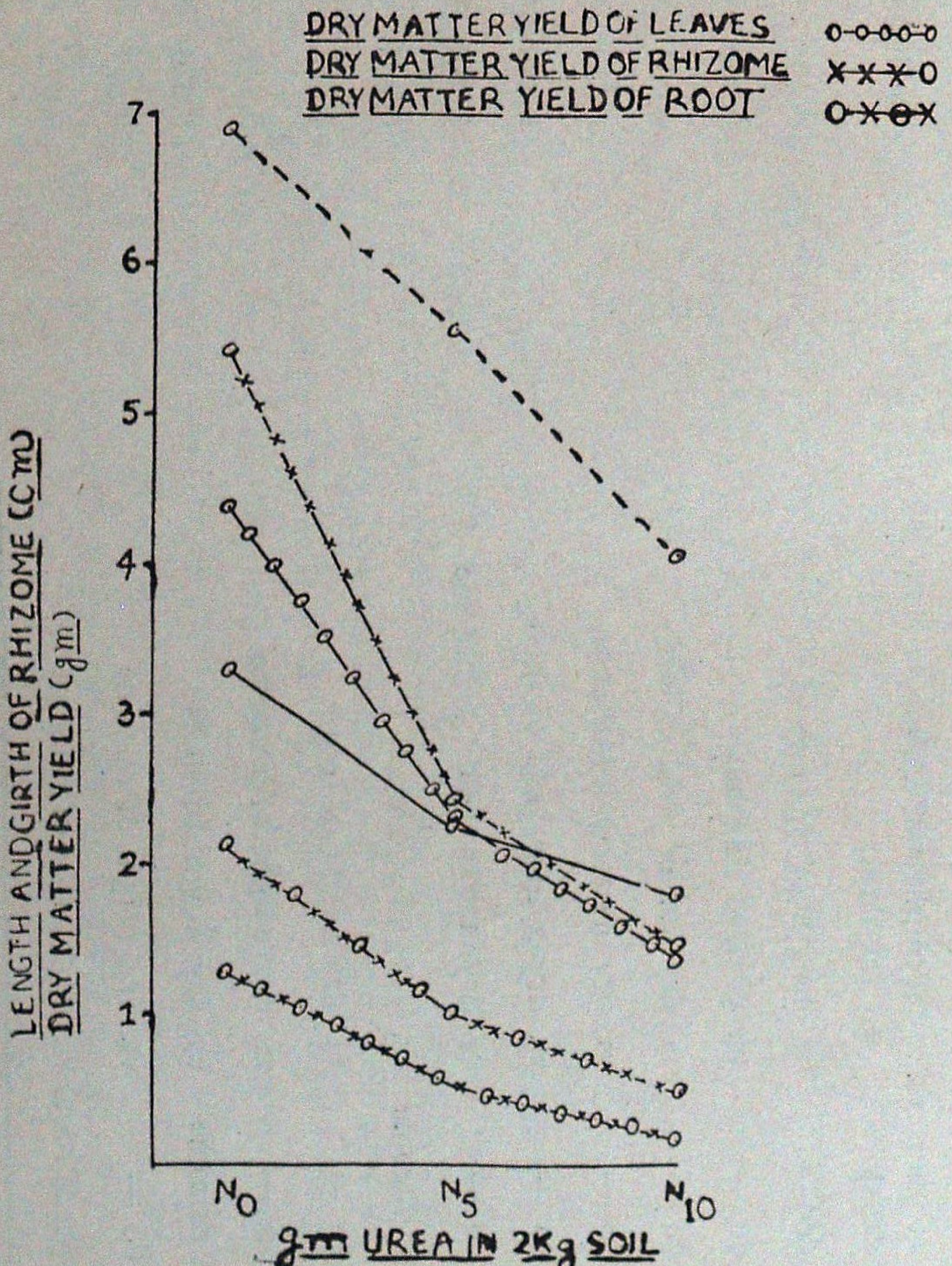
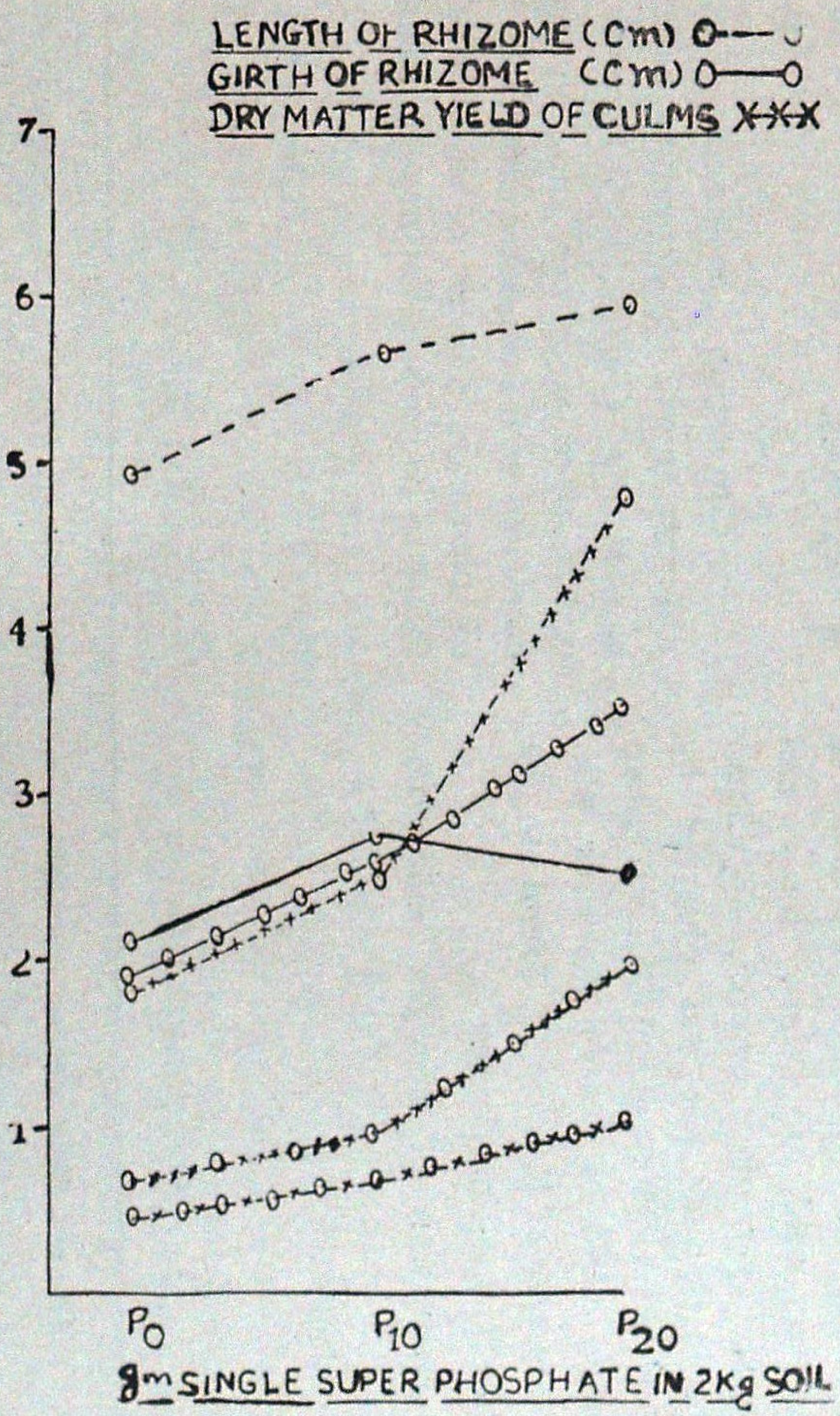


Fig. 4

Under the influence of Phosphorus



Mean length and girth (cm) of bamboo rhizome and dry matter yield of leaves, culms, roots and rhizome (gm) after 150 days.

Application of single superphosphate (Table 2, Fig. 4), significantly increased the dry matter yield of culms, roots and rhizomes, over the control. Significant increase in yield of root was observed by many workers (Russell, 1975). Though dry matter yield of leaves increases with increasing dose of P, it was found to be statistically non-significant.

Interaction of nitrogen and phosphorus was not found to be significant in all these cases.

Correlation coefficients between different growth characteristics have been worked out (Table 3). All growth parameters were positively and significantly correlated with each other except the height of plants vs. number of culms which was found to be positive but non-significant.

Table 3

Correlation coefficient between some growth parameters.

Growth Parameters		Correlation coefficient (r)	
Weight of plant (at 150 days)	vs. total number of culms (at 150 days)	+0.563	NS
— do —	vs. length of rhizome	+0.955	**
— do —	vs. girth of rhizome	+0 909	**
— do —	vs. dry matter yield of leaf	+0.908	**
— do —	vs. dry matter yield of culm	+0 849	**
— do —	vs. dry matter yield of shoot	+0.889	**
— do —	vs. dry matter yield of rhizome	+0.844	**
Length of rhizome	vs. girth of rhizome	+0.903	**
– do —	vs. dry weight of roots	+0.888	**
— do —	vs. dry weight of rhizome	+0.841	**
Girth of rhizome	vs. dry weight of roots	+0.820	**
— do —	vs. dry weight of rhizome	+0.693	**
Dry weight of roots	vs. dry weight of rhizome	+0.972	**

** Significant at 1%, NS — Not significant.

In conclusion it may be said that application of urea @ 5.0 gm and 10.0 gm/pot containing 2 kg soil has adverse effect on the growth and dry matter yield of bamboo seedlings. On the other hand single superphosphate @ 10.0 gm and 20.0 gm/pot containing 2 kg soil increases both the growth and dry matter yield of 5 month old bamboo seedlings. Experimental soils are fine textured in nature. It is, therefore, expected that these soils have high phosphorus fixation capacity and high P fertilization for higher yield under short rotational management conditions is required.

SUMMARY

An poly-pot experiment was conducted in factorial R.B.D. design with 4 replications to study the effect of nitrogen and phosphorus on the growth and yield of bamboo seedlings. Application of nitrogen @ 5.0 gm and 10.0 gm of urea/pot containing 2 kg soil individually as well as in combination with single superphosphate significantly decreased all growth parameters and dry matter yield. However, phosphorus application @ 10.0 gm and 20.0 gm single superphosphate/pot individually as well as in combination with nitrogen increased the height of plant, length of rhizome and dry matter yield. The correlation coefficients between some growth factors were calculated and were found highly significant. The results of this experiment suggest that with 'P' application better growth of bamboo seedlings may be obtained in short duration and healthy plantation stock could be made available.

नाइट्रोजन और फास्फोरस उर्वरीकरण का *डैंड्रोकेलेमस स्ट्रिक्टस* के पौधों पर प्रभाव

एन० जी० तोरे, अरुग प्रसाद, के० एम० कपूर, पी० के० खत्री, जे० एस० चौहान,
ए० के० भौमिक व वी० के० दहिया

सारांश

एकादिहत आर० बी० डी० अभिकल्प में चार दुहराव करते हुए बांस के पौधों की वृद्धि और प्राप्ति पर नाइट्रोजन और फास्फोरस का प्रभाव ज्ञात करने के लिए एक बहुगमला संररीक्षण किया गया। 5.0 ग्राम नाइट्रोजन और 10.0 ग्राम रिया/गमला की दर से, जिसम 2 किलोग्राम मिट्टी भरी हुई थी, अलग-अलग तथा अकेले सुररफास्फेट के साथ मिलाकर देने से वृद्धि के सभी परिमाप तथा शुष्क पदार्थ प्राप्ति सभी सार्थकतः घट गए। किन्तु 10 ग्राम फास्फोरस और 20 ग्राम अकेली सुररफास्फेट/ गमला अलग-अलग से तथा नाइट्रोजन के साथ मिलाकर देने से पौधे की ऊंचाई, शिफास्तम्भ की लम्बाई और शुष्क पदार्थ प्राप्ति सभी बढ़ गए। वृद्धि कारकों के सहसंबन्ध गुणकों की गणना की गई और वे अत्यधिक सार्थक पाए गए। इस सररीक्षण के परिणामों से पता चलता है कि फास्फोरस देने से बांस के पौधों की अधिक श्रेष्ठ वृद्धि कम समय में प्राप्त की जा सकती है तथा इस प्रकार रोपवन तैयार करने के लिए स्वस्थ रोपण-वस्तु उपलब्ध की जा सकती है।

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LETTERS TO THE EDITOR

(I)

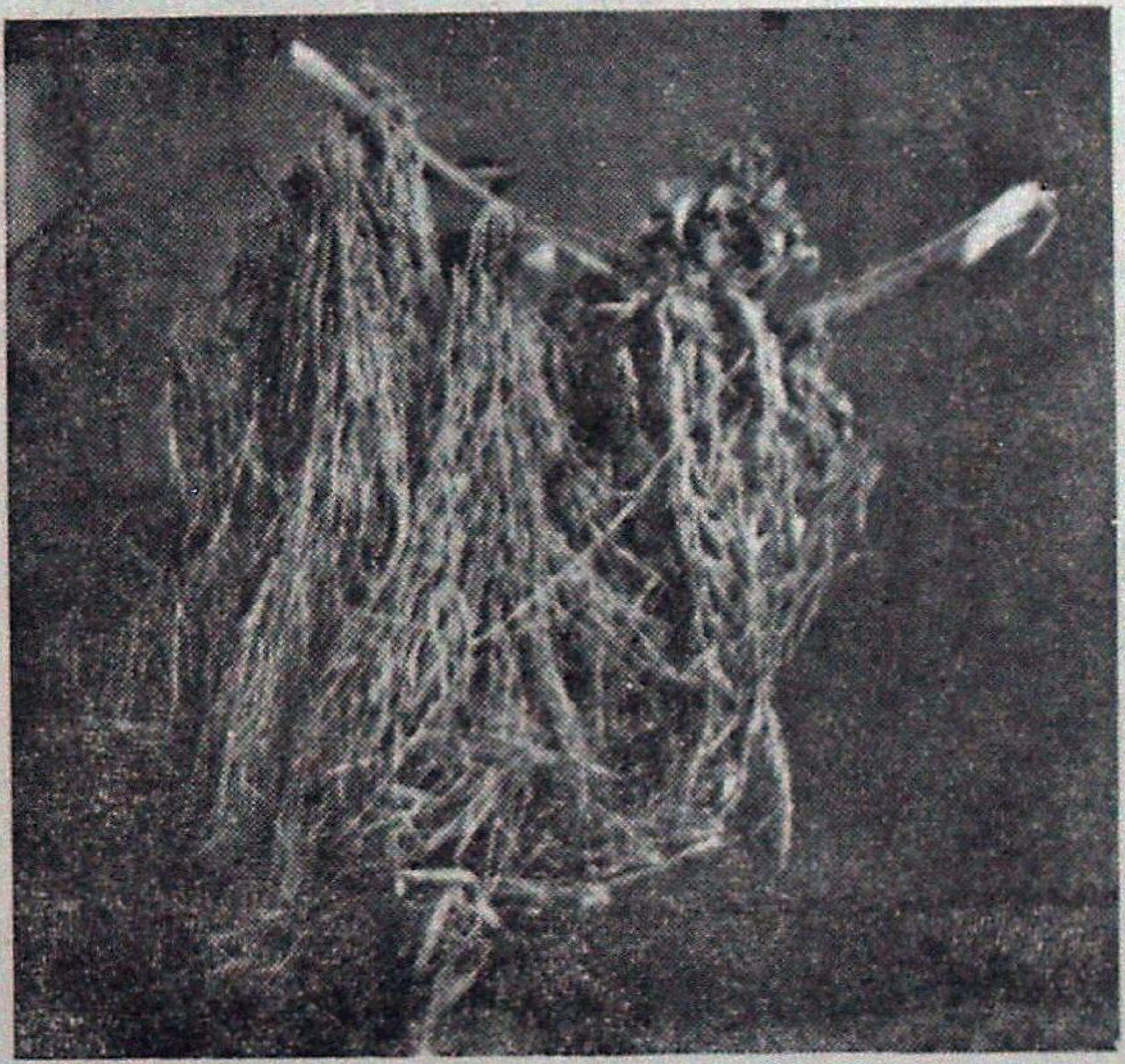
To,

The Hony. Editor,
Indian Forester,
P.O. New Forest, Dehra Dun (U.P.)

Sub : **Gregarious flowering of** *Bambusa arundinacea* **and** *Dendrocalamus strictus.*

Sir,

Gregarious flowering of both *Bambusa arundinacea* and *Dendrocalamus strictus* has occurred in the forest of Nallamalai hills, in Kurnool district during 1987-88.



Some of the clumps which flowered partially have number of culms exhibiting aerial development of rhizomes. This phenomena is seen mostly on *Dendrocalamus strictus.*

I have not come across such a phenomena elsewhere, earlier. Would any of your readers throw some light in this or a similar happening.

Thanking you,

Yours faithfully,
Sd./- M. Sitaram Rao,
Chief General Manager,
Andhra Pradesh Forest Development Corpn. Ltd.,
Hyderabad.

Dated : 28-5-88.

(II)

To,

The Hony. Editor,
Indian Forester,
P.O. New Forest, Dehra Dun (U.P.)

Sub : **Flowering and fruiting of bamboo *Melocanna baccifera* in North Cachar Hills, Assam.**

Sir,

This year, in June I found quite a number of culms of *Melocanna baccifera* in flower and fruit at Nanadisa. Some of the fruits even started sprouting. Some of the new shoot was already about 30 cm high. On the same day I found grove of the spp. in flower at Haflong.

Last recorded gregarious flowering of the spp. was during 1952-56. Gregarious flowering is always preceeded by sporadic flowering. This is, no doubt, the sporadic flowering before the gregarious flowering. The cycle of gregarious flowering of *Melocanna baccifera* is thirty years.

Yours faithfully,
Sd /- K.K. Gupta,
Divisional Forest Officer,
Southern Afforestation Division,
Hills, Haflong (Assam)

Dated : 24-6-88.

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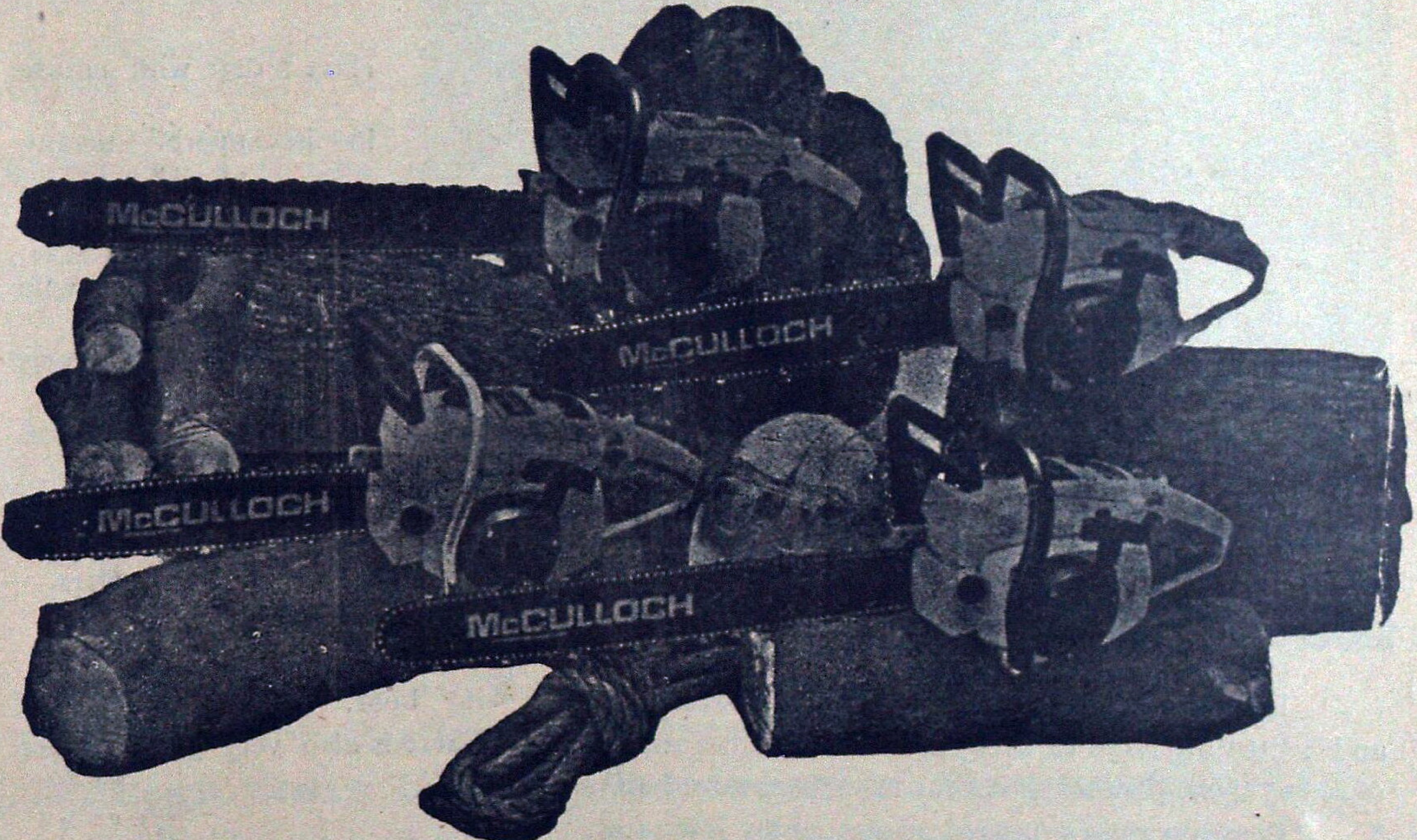

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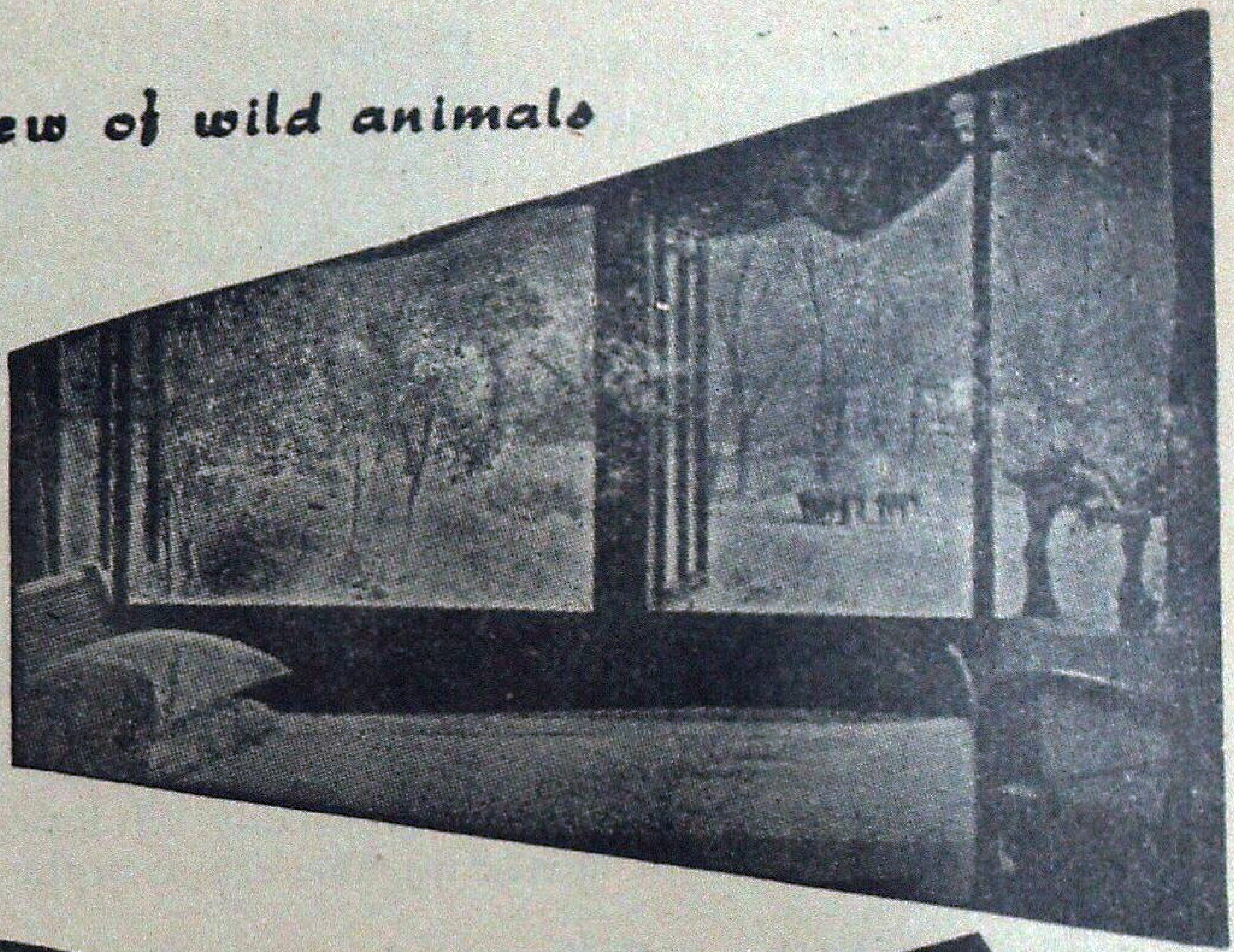

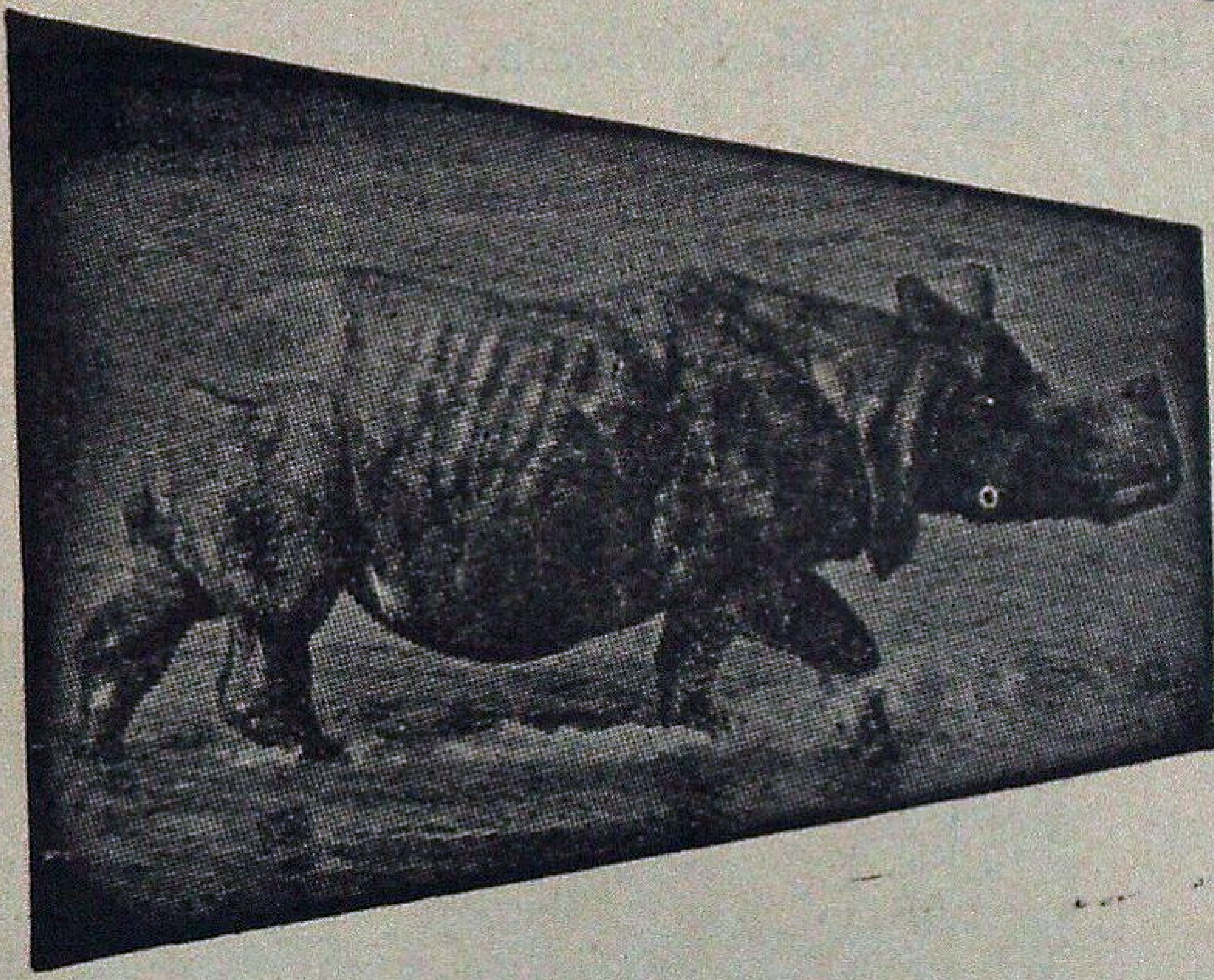

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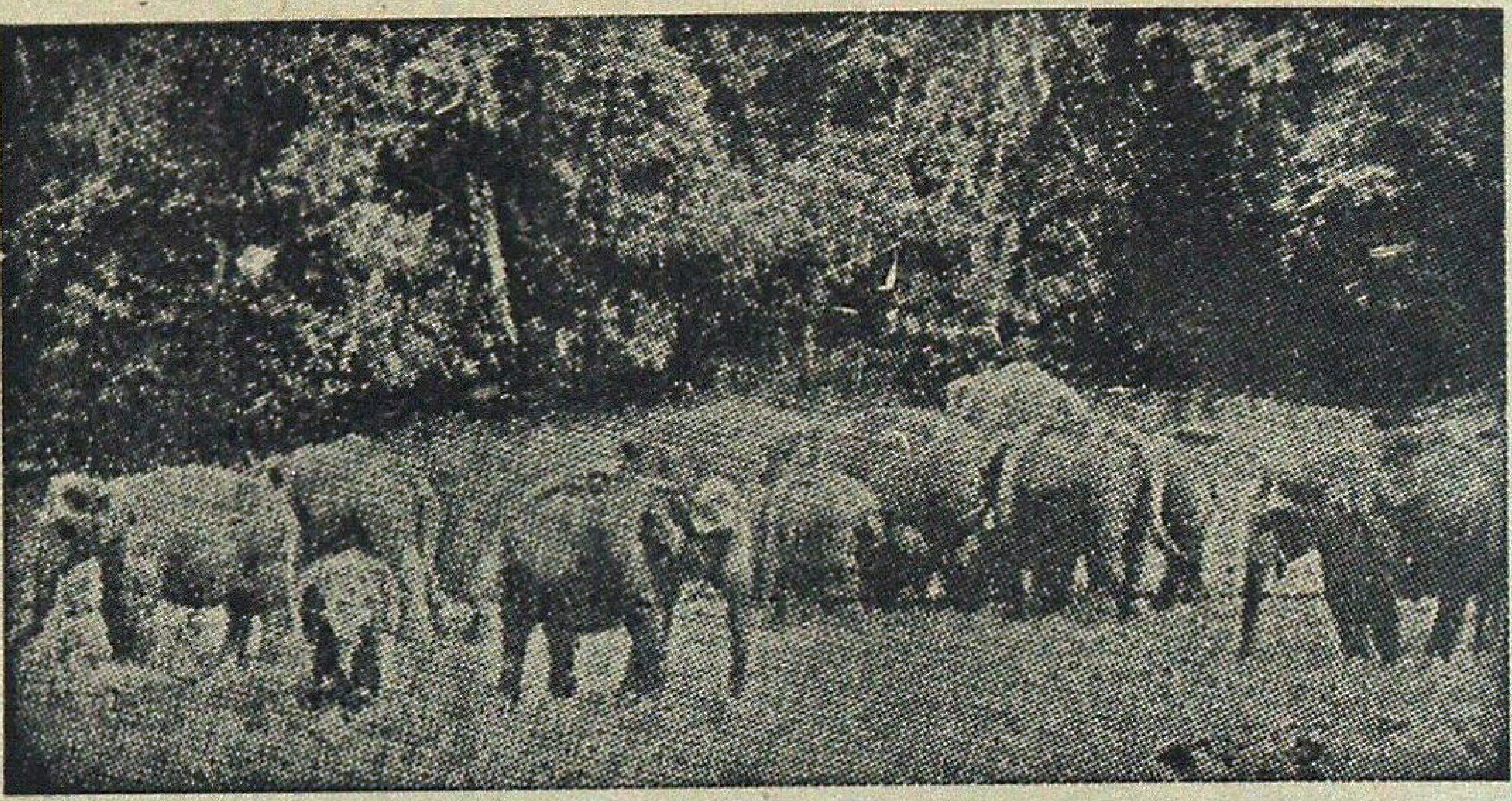

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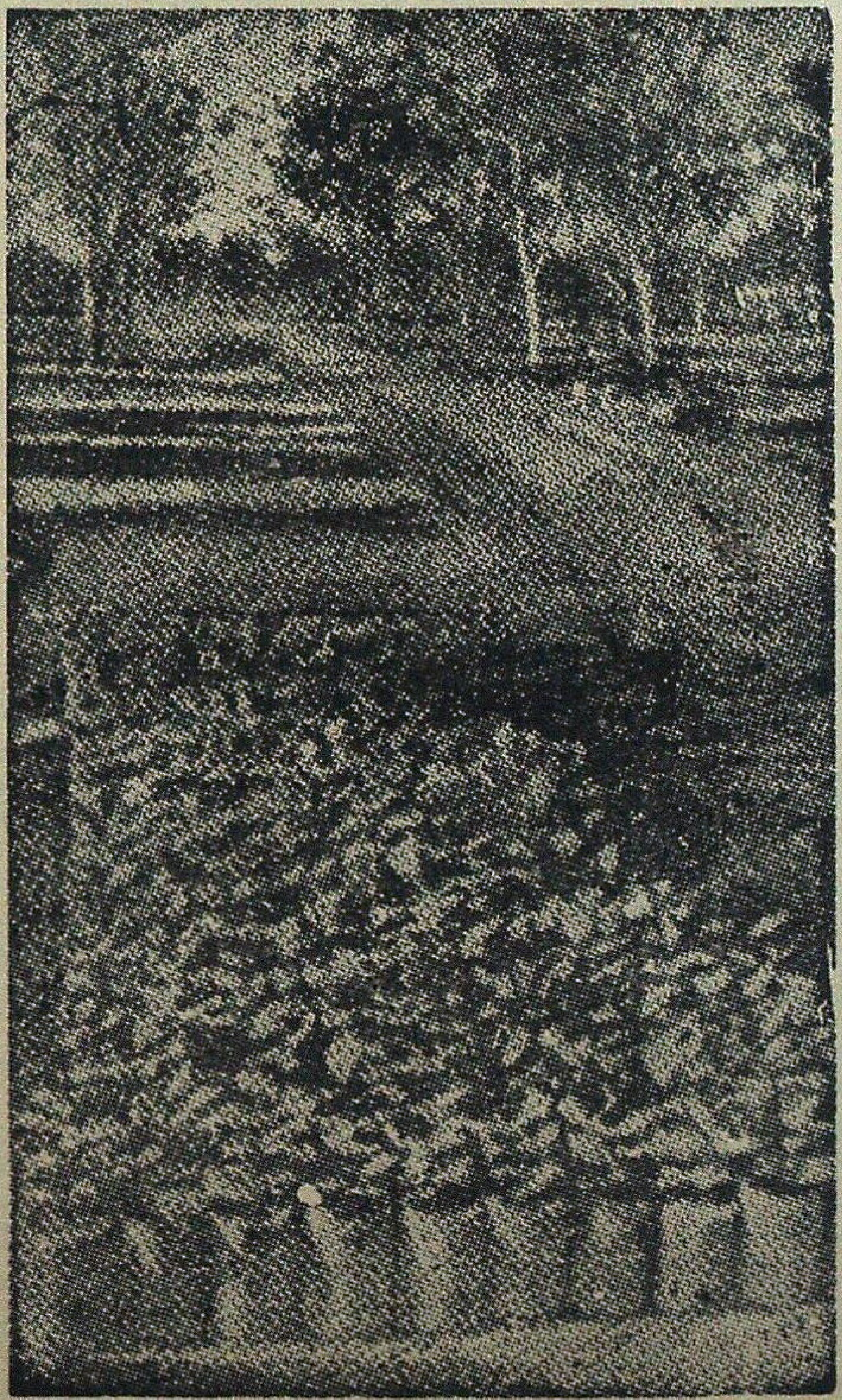

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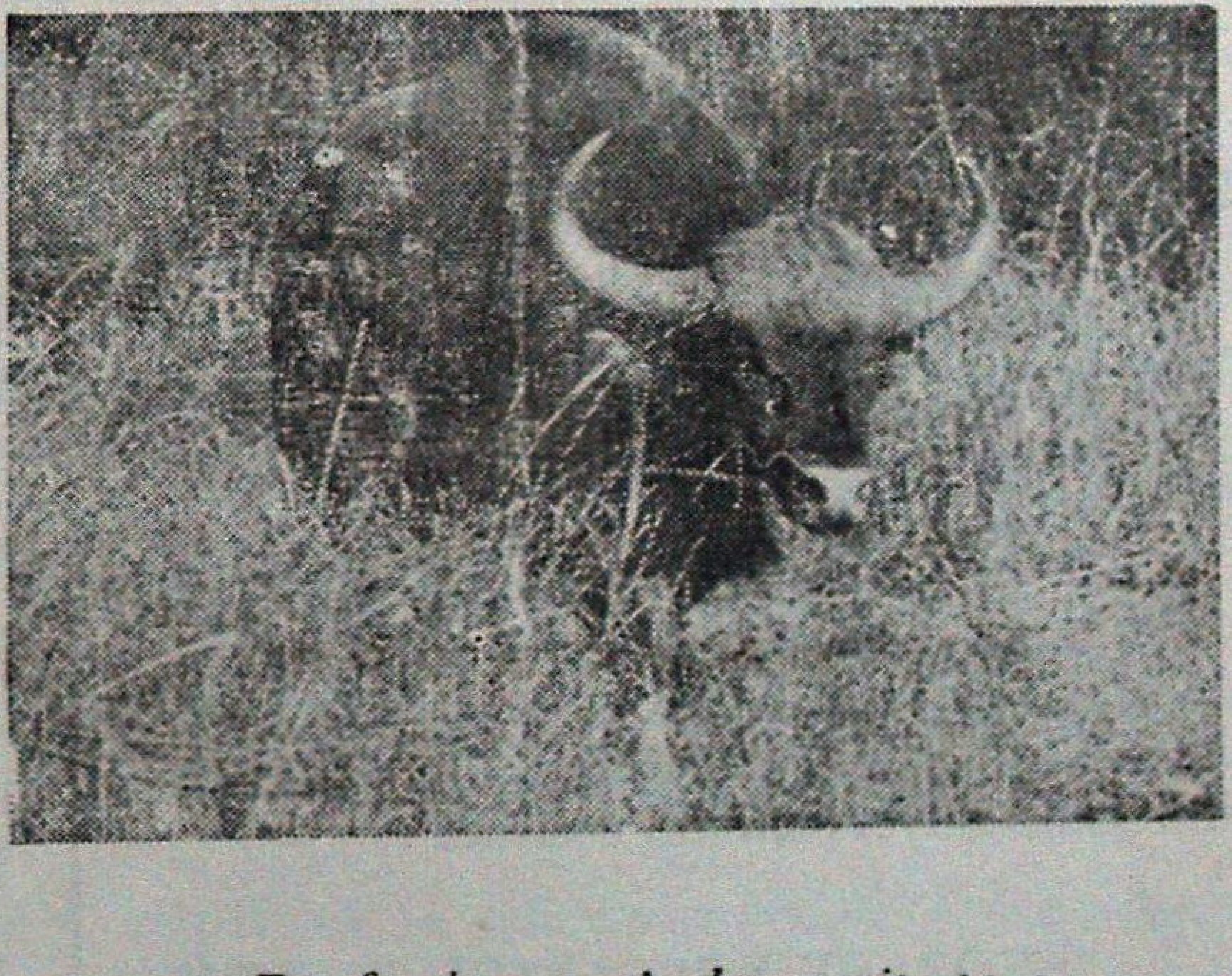

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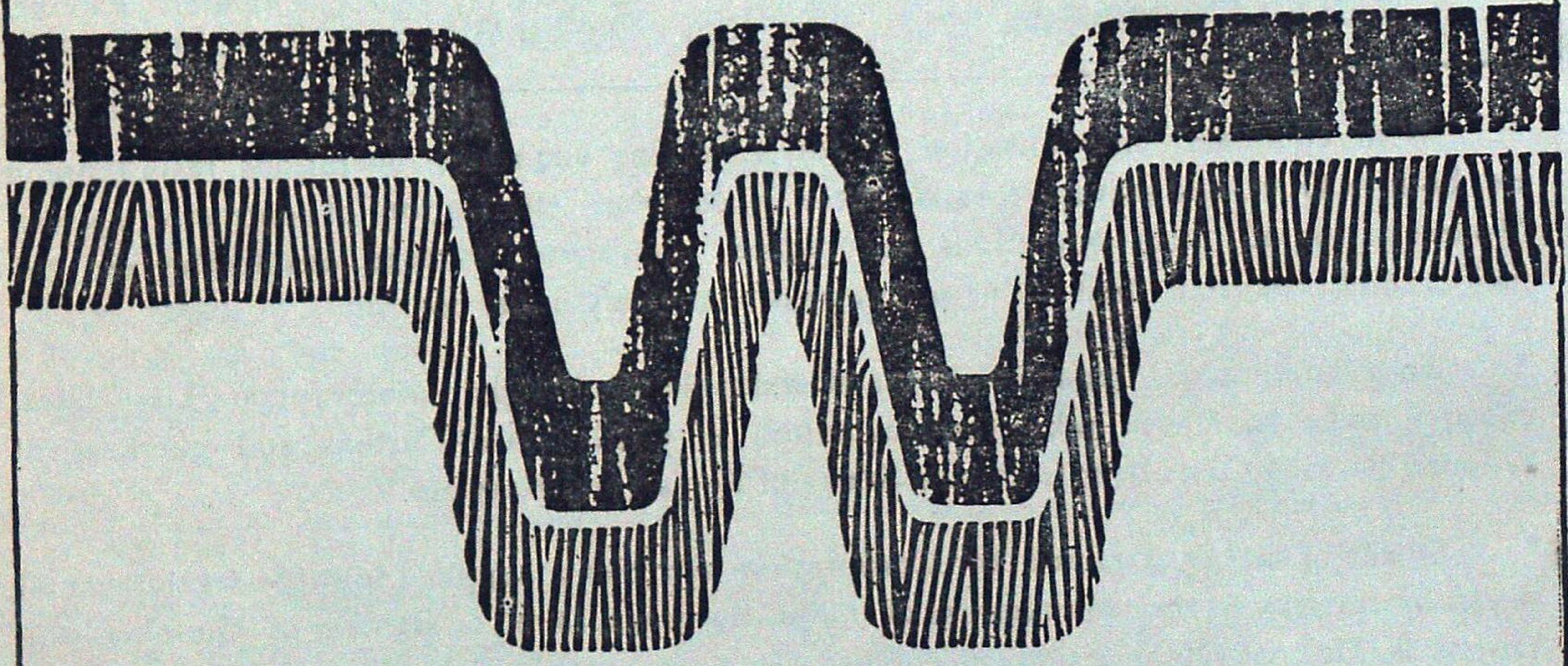

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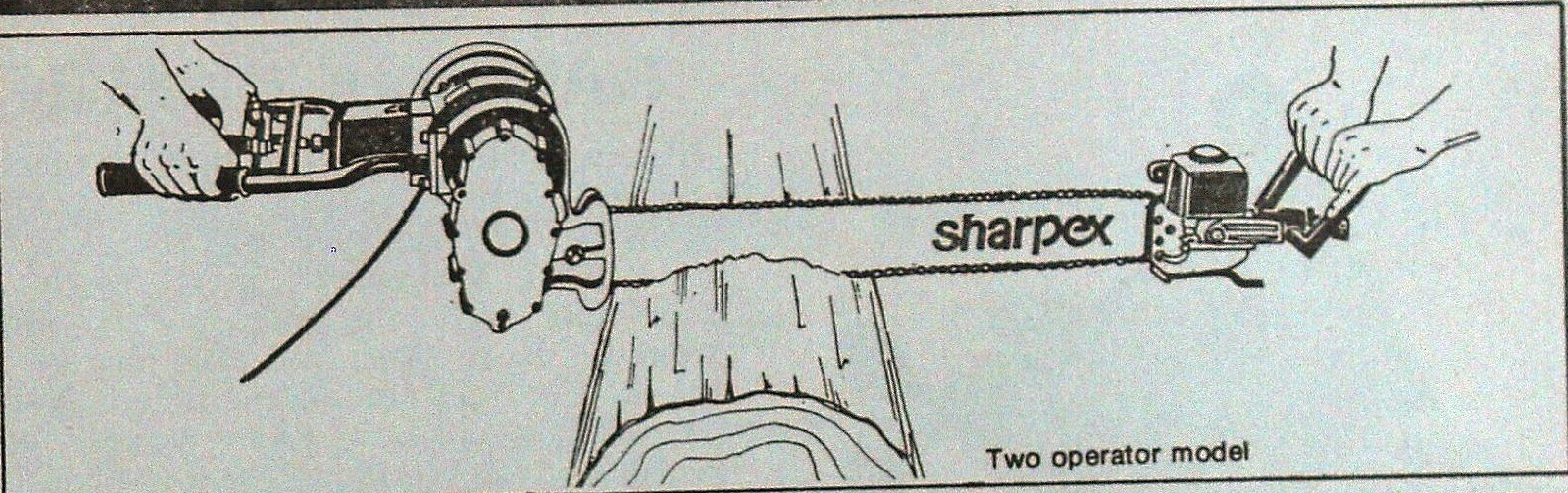
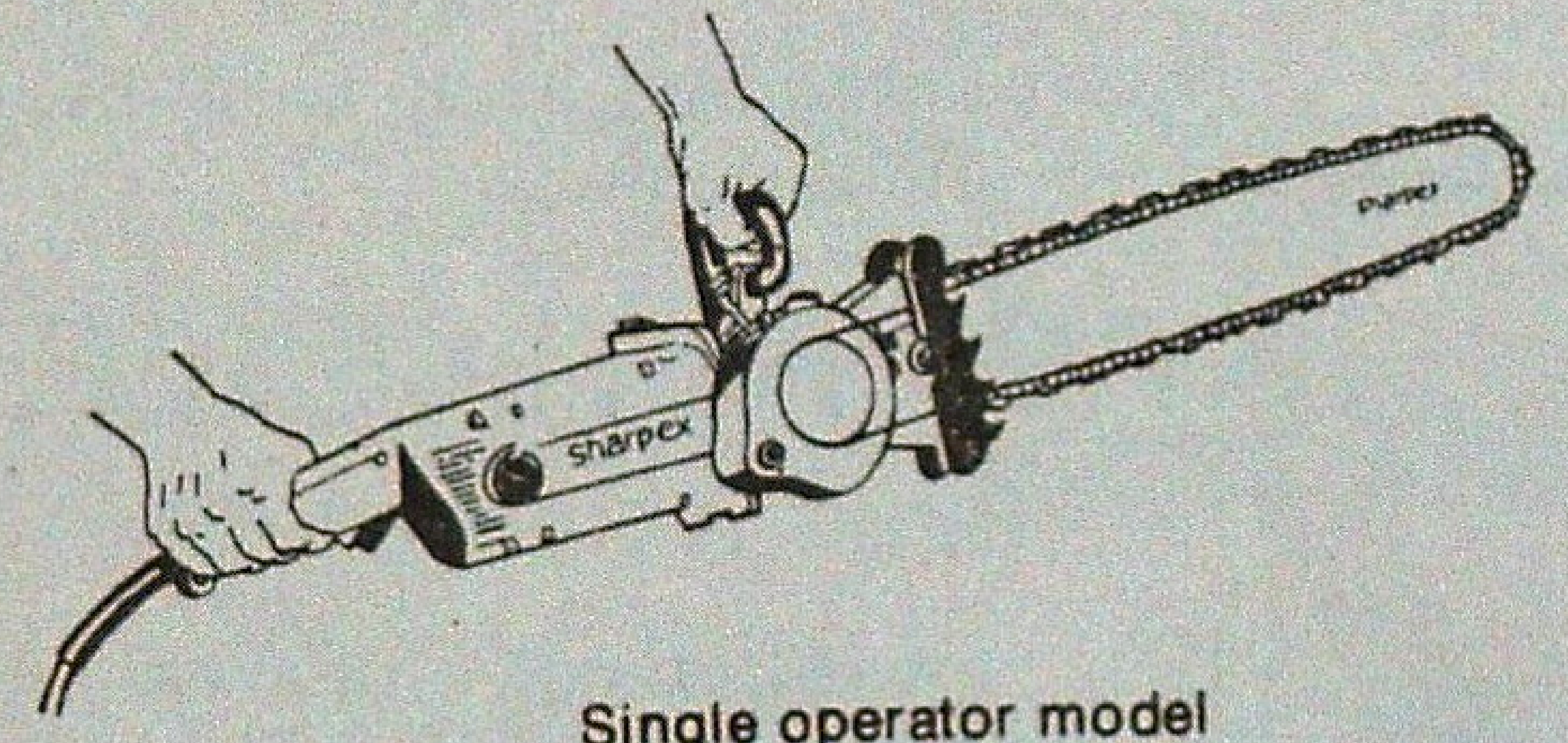


Two operator model



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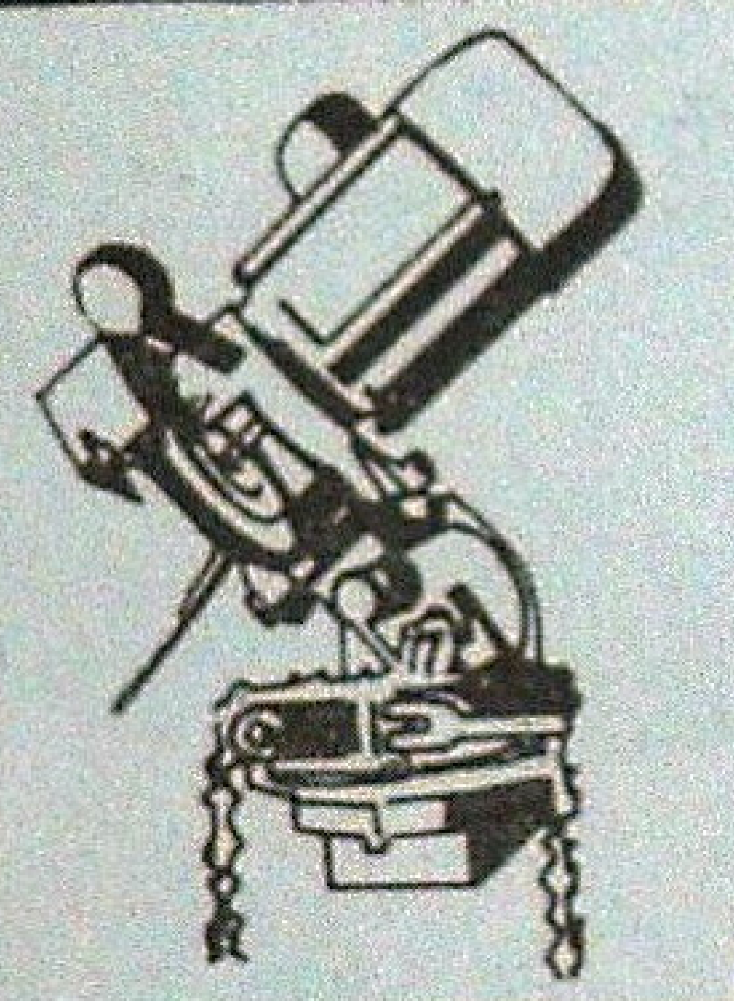

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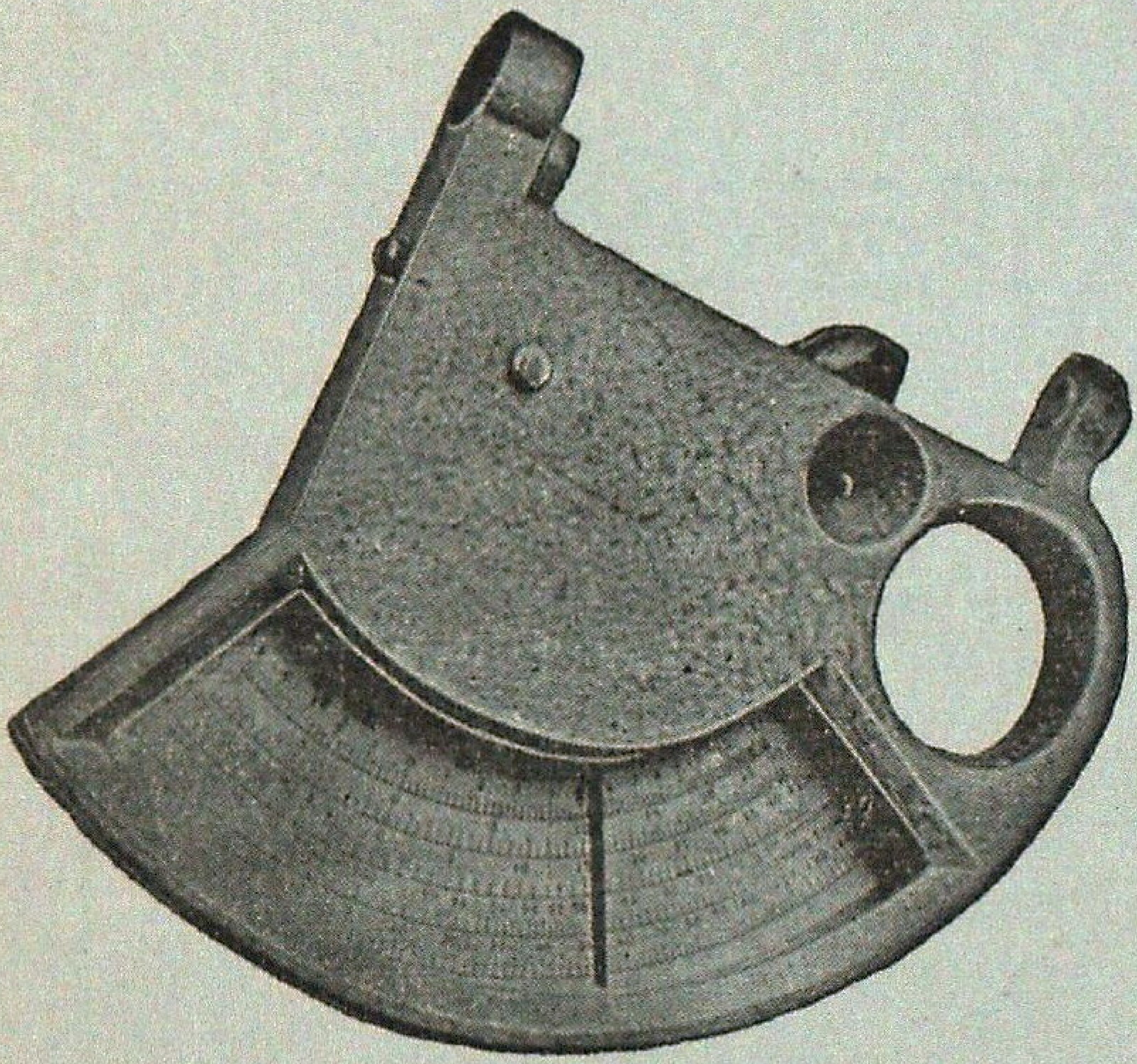

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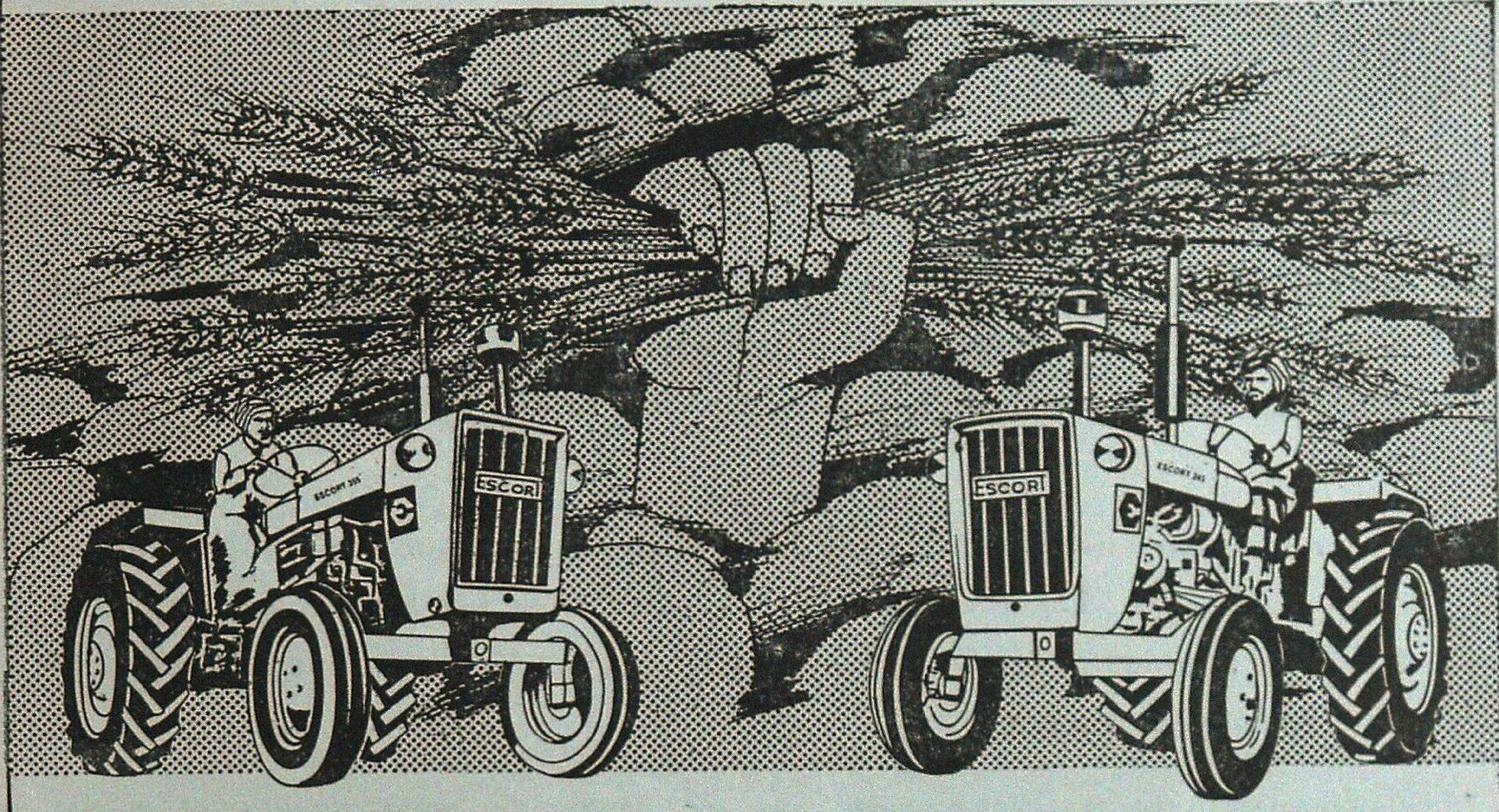

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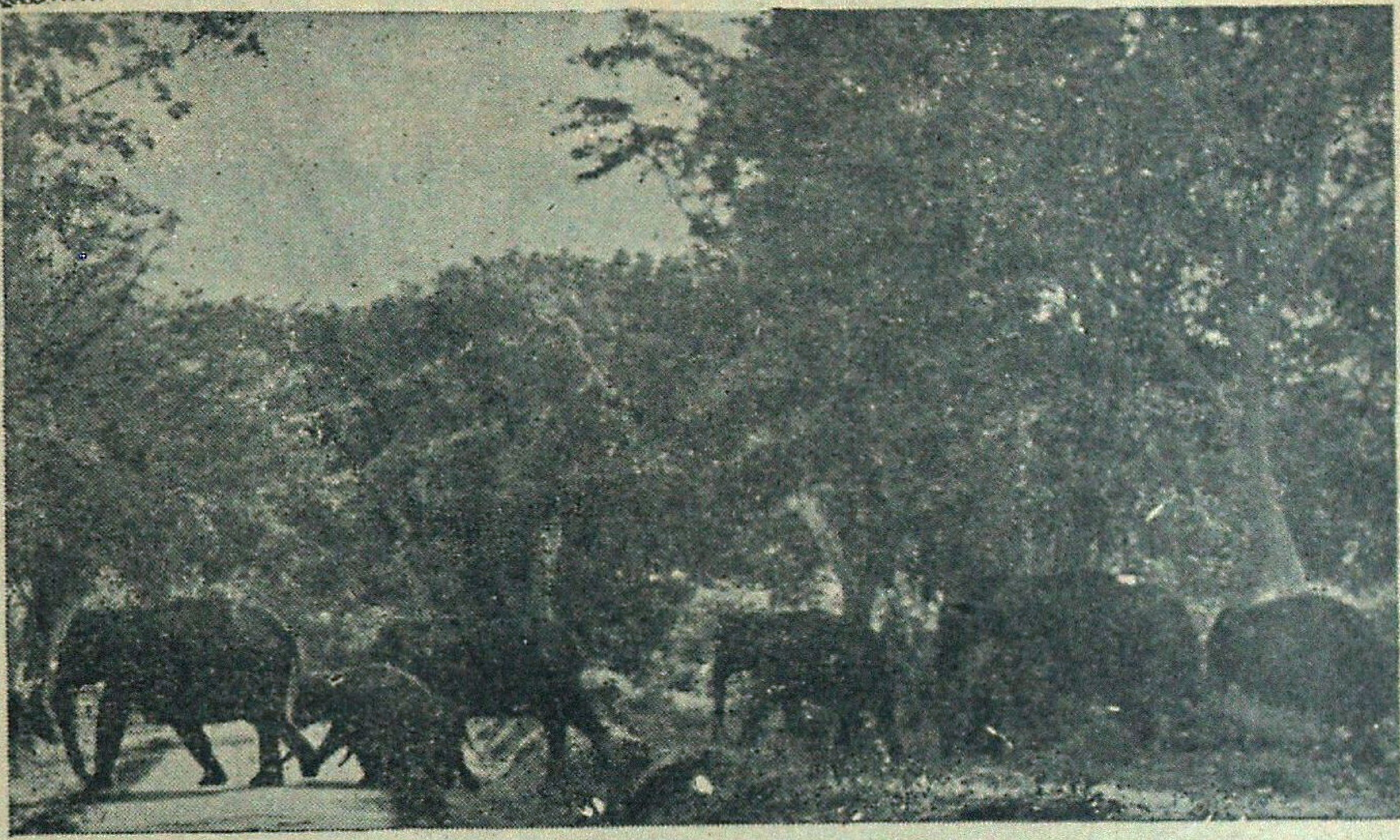

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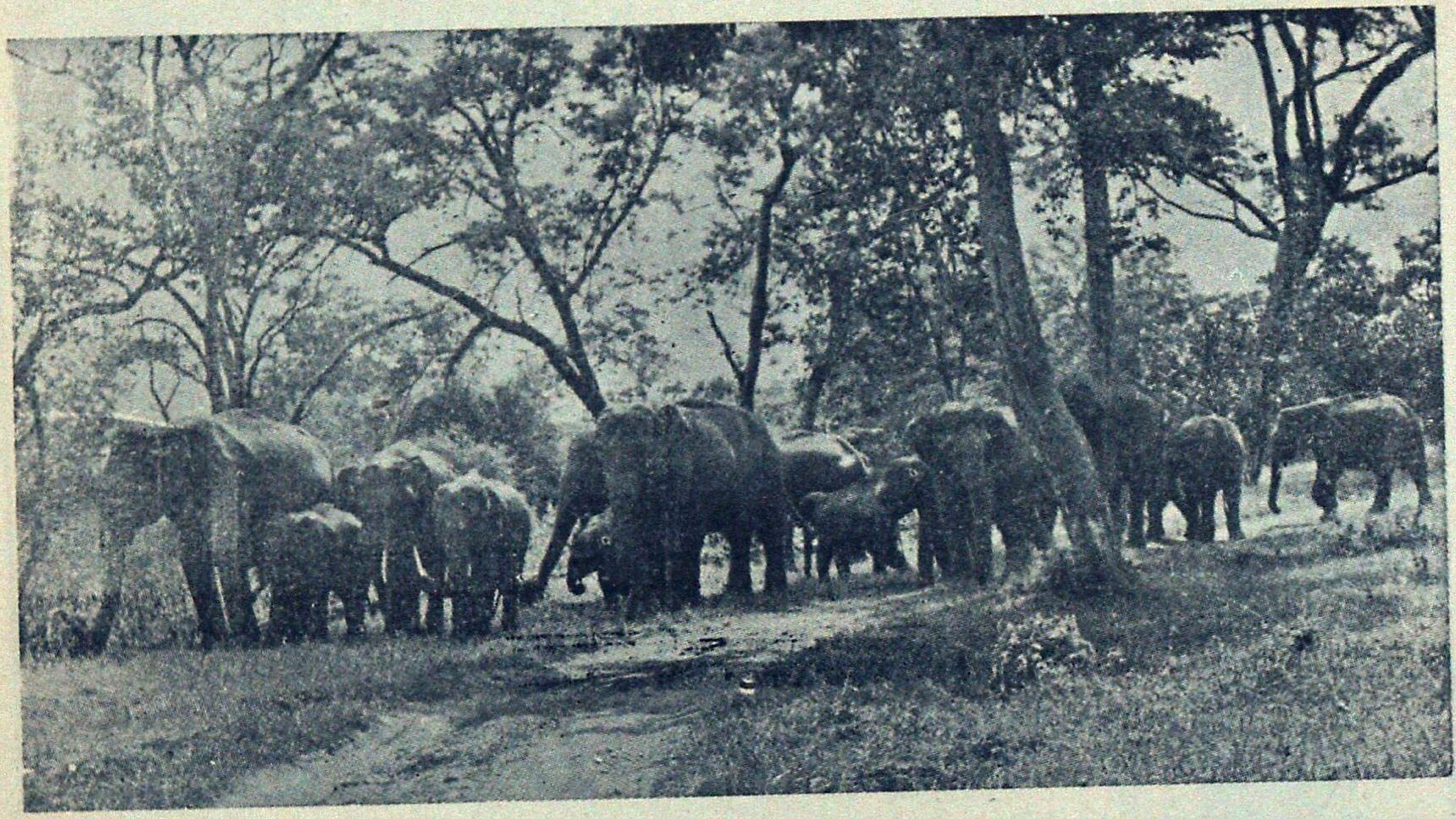

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Mizoram Forests Through The Years

During the British period i.e. from 1890 till the year 1952, the management of Inner Line Reserved Forests was done under the supervision of Superintendent of District. The District was put under 'Excluded Area' and practically no Statutory Act or Law were enforced to manage the Forests. Practically nothing had been done. The Inner Line Reserved Forests was constituted under the Assam Forest Regulation comprising an area of 559 sq kms.

When the Mizo District Council came into being in 1952, the management of all the Forest other than the State Inner Line Reserved Forests was handled by the District Council. Thence the District Council started to make its own Forest Wing. Under the District Council one Forest Division called Aizawl Forest Division was created comprising the then whole area with headquarters at Aizawl. In fact during the time of the then District Council, most accessible areas of the forests had been overtapped for earning more revenue and due to population pressures.

In the early 1960's the first plantations were raised by the District Council in different centres. During the year 1966—1968, practically no plantation could be raised due to political disturbance in the Mizo District.

After Mizoram became a Union Territory in the year 1972, the Union Territory Government formed one more Forest Division with headquarters at Lunglei.

The present position of Mizoram Forest Department may be summed up as follows :

The Mizoram Forest Department is headed by the Chief Conservator of Forests. The field work has been taken up with ten (10) Territorial Divisions. In addition to this, six (6) Functional Divisions have been set up. There are now three (3) Circles namely—Southern Circle, Northern Circle and Research & Development Circle. The Government of Mizoram has already constituted three Wildlife Sanctuaries in order to preserve its vanishing Wildlife. Four more Wildlife Sanctuaries are being proposed which are likely to be constituted very soon. The Mizoram Forest Department has created 1,00,029 hectares of plantation upto 1987 as against 967 hactares before it attained U.T. Status.

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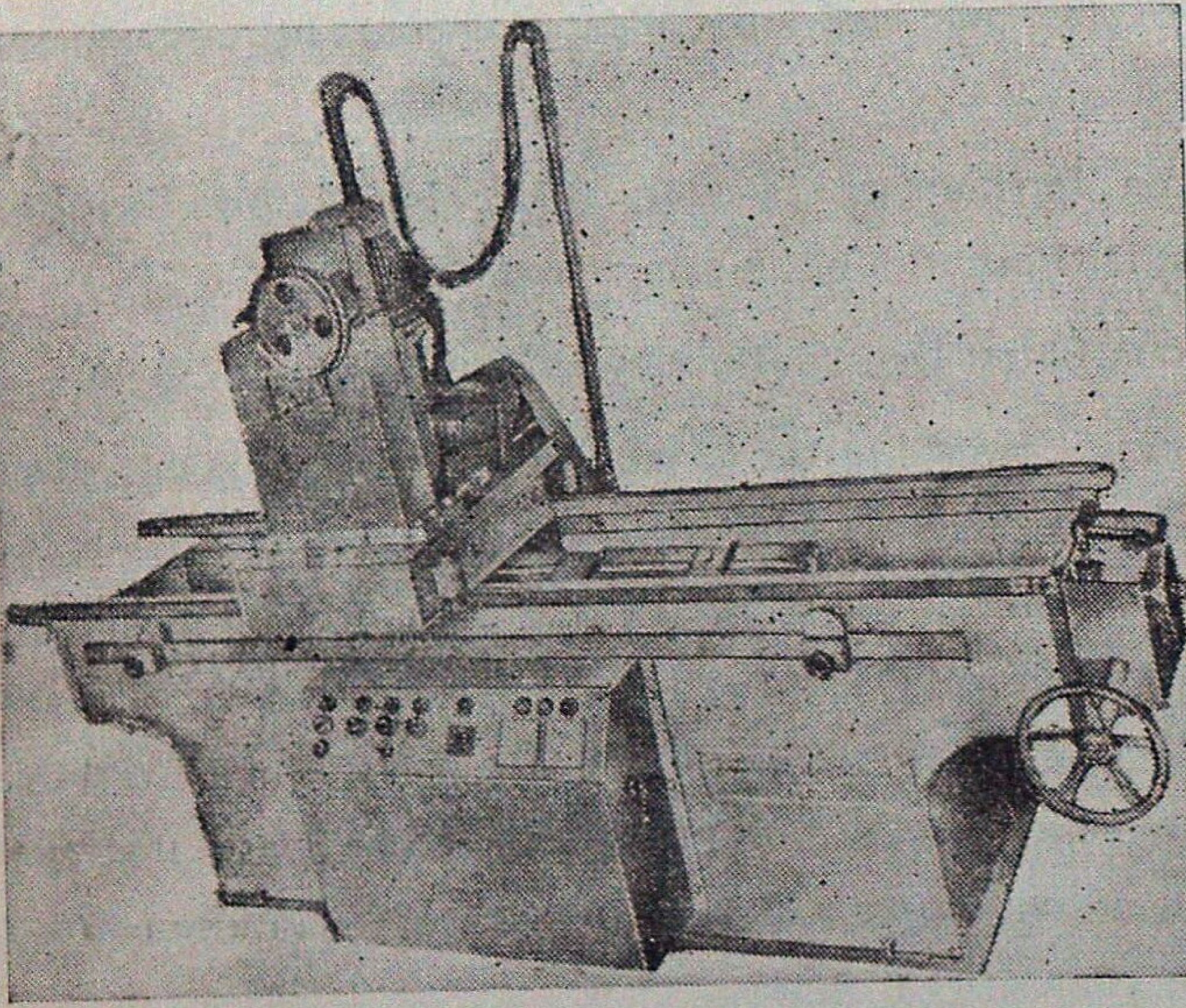

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Director, Forest Survey of India, Dehra Dun

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